A PROPOSED MEASUREMENT TECHNIQUE FOR MEASURING THE IMPACT OF A HUMAN RESOURCES MANAGEMENT PROGRAM ON THE UNITED STATES NAVY

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THESIS

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A Proposed Measurement Technique

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on The United States Navy

by

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ABSTRACT

This thesis explores the potentialities and survival problems of a Human Resources Management Program in the U. S. Navy and proposes a technique for measuring its potential impact on the naval organization. The intended application of this work is to the practice of human resources management in the context of the U. S. Navy from both a theoretical and practical viewpoint. The proposed measurement technique is designed to provide a type of "third level" information, more specific than currently exists, which is deemed critical to the real-time application of this emerging practice. The main premise of the thesis is that such contributions of increased analytical measurement capabilities in human resources management will be the critical factors at present in determining if, in reality, this "humanized" approach to naval management will pass its first test of survival in the existing organization. Such a test is its ability to define its role and capabilities to others and to produce some "scientifically acceptable" measure of its impact on Navy organizations.

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I. INTRODUCTION

A. BACKGROUND

On 29 October 1970, the Chief of Naval Operations approved a one year pilot program in human resources management. The perceived objective of this program is to develop, implement, and evaluate action programs, which will improve the overall effectiveness of the Navy through enhanced management of its human resources and through the development of an organizational climate in which the individual can better contribute to the accomplishment of the naval mission while concurrently meeting his own personal needs. Implicit in this objective is improved management through enhanced communications and better understanding of the Navy man as an individual.

B. ORIENTATION

The first challenge to this action from the Naval community seems to ask: "Is this another limited objective? Are we reacting to social pressures with a pacification program or are we seriously attempting a long range approach to a recognized and often neglected need?" It is assumed here that both the level of support and concept of this program imply expanded objectives and long range change activities in the future.

Such change is initially aimed at the human social organization in that it is only in this environment that actual communications and

better understanding of the Navy man as an individual can occur. Much has been researched about human organizations and it is not the purpose of this thesis to retrace this ground. Rather a brief introduction of it here in the context of this thesis is presented.

C. THE HUMAN ORGANIZATION

An initial description of the human organization is the attempt to understand its structure. It is not a formless aggregate of interacting individuals engaged in the creation of some random combination of events. In the most generic sense the structure of the human organization is contained in its various functions. The proposed diagnosis of the needs of the human organization is done on three levels of analysis. These attempt to describe the health state, the symptomatic state and the etiology of its disorders ("third level" information).

It is premised that an effective human organization cannot exist without the habitual realization by its members of three factors: their expected activities, the understanding and skill needed for the performance of those activities, and motivation to engage in that performance. The first two factors are deemed essential if the individual is to better contribute to the accomplishment of the naval mission; and the third can only come about if the individual is concurrently provided an environment in which he can meet his own personal needs.

Thus, human resource management programs which meet the stated objective must provide for the activities that accomplish the

above functions. Such a set of activities, required of every Navy man, constitutes his role. At one level of conceptualization, then, the human organization is considered a structure of roles and the various role functions in which its members are engaged.

D. ANALYSIS AND THE NATURE OF CHANGE

Analysis and attempted measurement of such roles is proposed along two dimensions -- those perceived and those preferred. The initial diagnosis of the resulting measures of difference along these dimensions defines the types of change necessary for creating the organizational climates in which the "individual can better contribute to the accomplishment of the naval mission while concurrently meeting his own personal needs."

Such change is assumed to be an attempt to alter behavior at both the top and bottom of the naval organization. Argyris (1), one of the leading researchers in this area, recommends two approaches to this effort -- laboratory training and restructuring of the human organization (a redesign of roles). He recommends that laboratory training only be used with management groups, as behavior at the top is considerably influenced by skill in interpersonal relationships.

Argyris views behavior at lower levels to be largely determined by technology and control systems, and that they can be changed only by new thinking about job design, controls and the authority system. This supports the premise that enduring change implies not only

individual motivational changes, but structural changes within the organization and in its relationship to its environment. Failing the attainment of such new equilibria, the change effort would be assumed to be absorbed and the organization returned to its previous level of functioning.

E. GOAL: ORGANIZATIONAL EFFECTIVENESS

It is deemed that enhancing the management of human resources and development of desired organizational climates through several levels of change is the only way to bring about an improvement of the overall effectiveness of the Navy. At the individual level, organizational effectiveness is viewed in terms of three generic requirements -- (1) joining and remaining in the organization, (2) performing dependably the assigned activities, and (3) engaging in cooperative behavior in the service of the Navy's objectives. The first requirement directly addresses the number one problem in the Navy -- that of retention. Improvement in this area seems to be the most focal issue. Performance, the second requirement, relates directly to other recognized problem areas -- mutual reports of poor performance about each other from commanding officers and junior officers, reported conflicts among junior officers and chief petty officers, and expressed desires for better management training. The third requirement of cooperative behavior applies to the remaining major problem areas -- those of minority affairs, drug abuse, and dissent. It is premised that the

motive patterns for minimizing these problem areas are not the same, nor will the same conditions necessarily arouse all of these motive patterns.

What is envisioned on the organizational level, then, is that the organization faces the problem of what mix of conditions (specific changes in climate) it seeks to create for what sectors of the organization in order to achieve given types of effectiveness (i.e. minimize some of the aforementioned problem areas individually).

F. NEEDED: A "SUCCESS" MEASURE

Given the above potential mix of change efforts required, the problem remains to somehow demonstrate the effects of any induced change. This is not only important for the information of the service organization (i.e. the pilot Human Resources Management Group) effecting such change, but for gaining acceptance from top naval management, as well as future clients (other naval organizations). Such "measurement" of results and "success," no matter how scientifically approached, ultimately involves an assignment of values. The objective of such a task is to structure subjectivity (responses to perceived and preferred organizational climate) in a way that some value assignments to "change" can be produced relative to subsequent responses about perceptions and preferences regarding organizational climate.

A method using multi-dimensional scaling is proposed in this thesis to "map" such perceptions and preferences based on judgments of rank

order and similarity. This is the "third level" analysis which is attempted to provide more structural subjective information regarding the etiology, or origins, of various symptoms of organizational climate. This proposal is not an attempt to reduce the human component to numbers. Rather it is a systematic attempt to further define individual and organizational relationships by examining gaps in perception and assigning values to them. The validity of this approach is supported by an emerging range of research in psychometrics, marketing, and the behavioral sciences (2), (3), (4). The interdisciplinary mix resulting in the analytical measurement device proposed is the author's most promising and original attempt to date to meet the need for this critical "measurement" function in human resources management.

G. ORGANIZATION OF THE THESIS

The introduction has described the background and orientation of a pilot Human Resources Management Program. In doing so it has discussed the human organization as the focal point of such a program. Enhanced management of human resources is aimed at improving the overall effectiveness of the Navy. As pointed out, the problem remains to somehow demonstrate or measure whether the changes implemented are achieving such effectiveness.

The next chapter of this thesis breaks this overall problem into its component parts. First, it discusses the most immediate problem of short-term human resources management program survival.

This survival is viewed as depending upon the program's ability to proceed through three stages of development, in which the areas of role requirements and client acceptance are most crucial. In progressing from being able to develop the necessary roles to gaining client acceptance, marketing efforts and measurement techniques are needed. Concepts of both are discussed at an intuitive level in Chapter II.

From this point on, the approaches to measurement (the key to implementing such a pilot program) are further defined. Chapter III explains the qualitative approach proposed, which is conceptually based on research performed by Rensis Likert. Potentials and limitations of such a measure are discussed. The quantitative measurements proposed appear in Chapter IV. Using the emerging tool of multi-dimensional scaling, an attempt is made to structure subjectivity in an effort to study the causes behind symptoms of organizational ill health. Defining such causes provides standards by which measurements of human organizational change can be made. The conceptual approach and application of this technique are discussed. As a final step, a descriptive guide to the evaluation of the outcome of the application is given along with suggestions for further experimentation.

Chapter V then summarizes the thesis and draws conclusions regarding the potentialities of the pilot Human Resources Management Program and the proposed technique to measure its impact. The Appendices contain all supportive material, technical explanations, and the computer programs used in the analysis.

II. THE PROBLEM SETTING

The foremost problem facing the Human Resources Management Program (HRMP) is seen to be its short-term survival. Being required to operate in the current management environment, the program must face such pragmatic questions as:

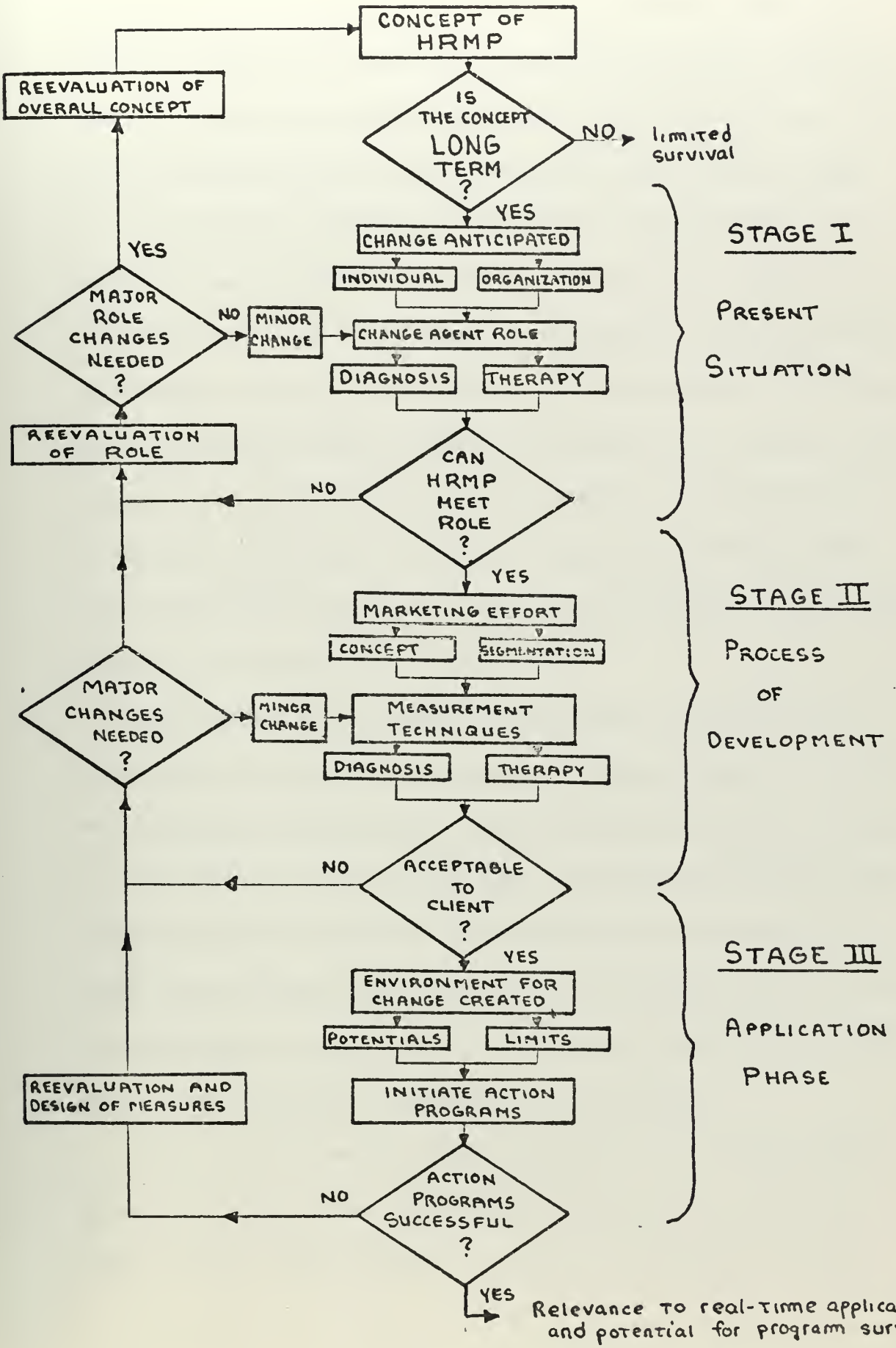
- Can it meet its proposed role?
- Is its role acceptable to the clients it intends to serve?
- Assuming some changes are induced, can these be measured?
- Considering all of the above, can such a program be judged cost-effective?

The premise is that unless the program has an approach to meet these requirements, its survival in the near term is tenuous. This chapter explores such an approach by defining the problem setting, proposing potential HRMP roles, and depicting the nature of action programs as seen by the author.

Central to the understanding of these concepts are several figures. Figure 1 graphically depicts the problem setting in general. Stage I is the present perceived situation of the HRMP, Stage II is the perceived process of development in which it is currently engaged, and Stage III is the potential application phase.

In Stage I, it is assumed that the nature of HRMP activities is long term. This implies bringing about anticipated changes at both

FIGURE 1. PROBLEM SETTING



the individual and organizational levels. The HRMP (change agent) activities designed to create this change define its role. In general this role is depicted as that of diagnosing organizational illness and prescribing therapeutic measures to induce organizational health.

At the interface of Stages I and II is the critical question of whether or not the HRMP can meet the role described. If not, re-evaluation of the role would need to be considered. With only minor role changes required, the HRMP would make functional adjustments in its organization until it can meet its redefined role. If major role changes are required, the nature of the HRMP concept would have to be reviewed to determine if long-term application is still feasible. Thus, this problem cycle would continue until the HRMP could ultimately meet the requirements of a long-term role.

Once in Stage II, the HRMP is faced with a marketing effort. Divided into two functions labeled concept and segmentation, the effort must market its ability to meet client needs and to be able to respond to a diversity of organizational needs. An operational procedure for implementing both concepts is proposed through measurement techniques which attempt to map gaps in client perceptions and preferences. Such mappings are to be used as a diagnostic tool and the therapeutic measure for change to be implemented by the HRMP.

At this point of interface between Stages II and III the question arises as to whether this entire effort is acceptable to the client. If not, and only minor changes in technique are required, various

measurement approaches (i.e. more direct questions aimed more sharply at specific areas) would be tried until acceptance is reached. If repeatedly major changes are needed, a reevaluation of the HRMP role would be in order. Looping through Stage I and Stage II would continue until there is a general acceptance for the work of the HRMP. Then, and only then, would an actual long-term change environment be created.

Considering the potentials and limitations of such change, initial action programs would be implemented and evaluated in part by the proposed measurement technique. If these programs are judged successful, the HRMP will have passed its test of short-term survival and demonstrated its relevance to real-time Navy problems. An unsuccessful program would call for reevaluation and design of measurements. Thus, the cycle would continue to loop through the respective stages until operational satisfaction is achieved. Graphically, this entire process is depicted in Figure 1.

At this point the critical areas of role requirements, marketing, preference and perception mapping, and measurements are further discussed.

A. ROLE REQUIREMENTS

In order to define the potential role requirements of the HRMP, the potential scope of the program is first envisioned. Figure 2 is central to this definition and depicts the potential scope as having

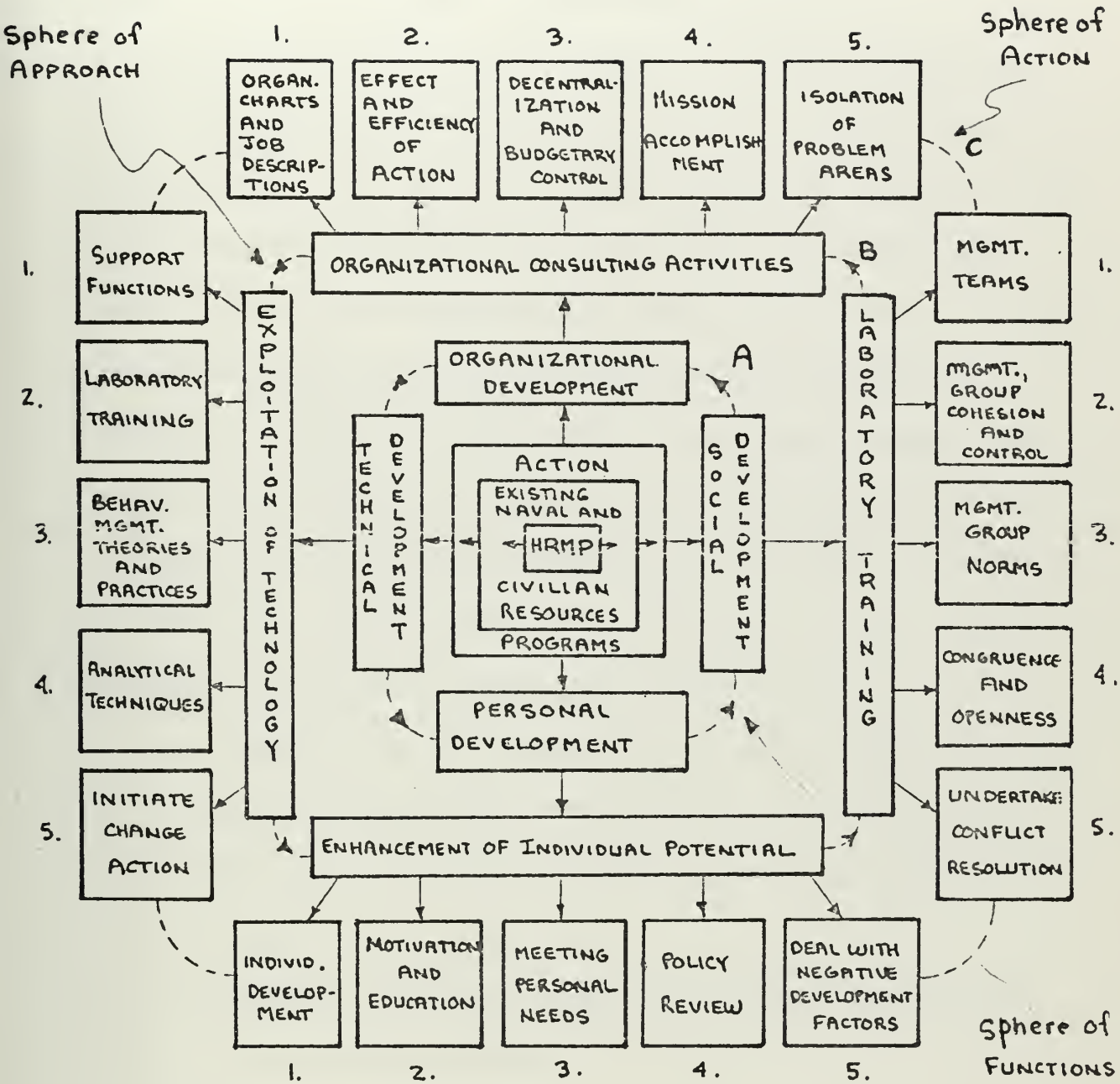


FIGURE 2.

HRMP POTENTIAL SCOPE OF APPLICATION

multidimensional functions in personal, social, organizational, and technical development. These functions would be met through action programs developed through existing civilian and military resources with the HRMP as the central coordinating resource.

The main role of the HRMP is then seen as one in which it helps to solve problems at all levels through providing a mix of capabilities aimed at flexibly dealing with particular problems as they arise. However, it should not be looked to as a cure-all nor be judged on that basis. Its role is best thought of as a responsive multidimensional resource capable of enhancing the desired types of organizational climate in which the goal of contributing to the accomplishment of the naval mission while concurrently meeting personal needs can be met.

More specifically, several approaches are envisioned in fulfilling the HRMP role. These, listed below, are elaborations of the items described in the "sphere of approach" shown in Figure 2.

- Modification of job designs (roles), controls and the authority system for the greater enhancement of individual potential
- Laboratory training for the development of managerial social skills
- Consulting activities as needed and requested for advising organizational leadership
- Exploitation of technologically advanced methods of human resource management.

Since the HRMP would be dealing with diverse problems, its action recommendations in each case will depend upon the particular frame of reference from which each particular problem is diagnosed. Each frame of reference is conceived more fully through the flow of attention depicted in Figure 3. The components of decision flow in this figure depict a particular course of action to be derived from an empirical referent applied to a way of thinking backed by a body of knowledge and filtered through a system of values. The "sphere of action" in Figure 2 depicts the outcomes of the various HRMP functions as occuring in this flow. Each number by which these outcomes are designated corresponds to the numbered components of the decision flow in Figure 3.

Functionally, the continuous action spectrum (based on the number 5 outcomes) that combines the various frames of reference is shown in Figure 4. This figure displays the relationships between the various frames of reference, the potential courses of action available to each, and the objectives towards which such action is intended. As shown, each frame of reference has an appropriate resultant course of action which has a continuous influence on action meaningful in the other frames of reference. When oriented towards specific goals, these courses of action are each directed toward particular objectives which, in combination, are directly related to the ultimate goal of enhanced organizational effectiveness. Capability of the HRMP to function in this manner is seen to be a measure of its ability to meet

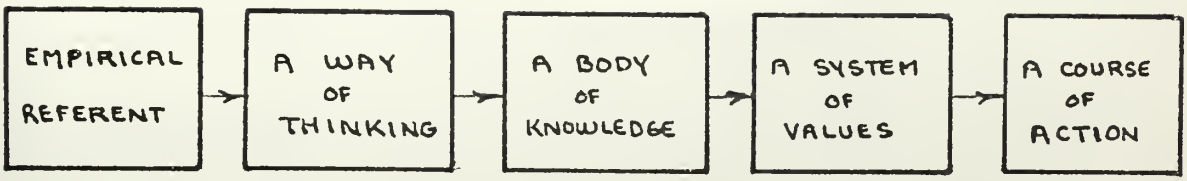


FIGURE 3.
COMPONENTS OF DECISION FLOW

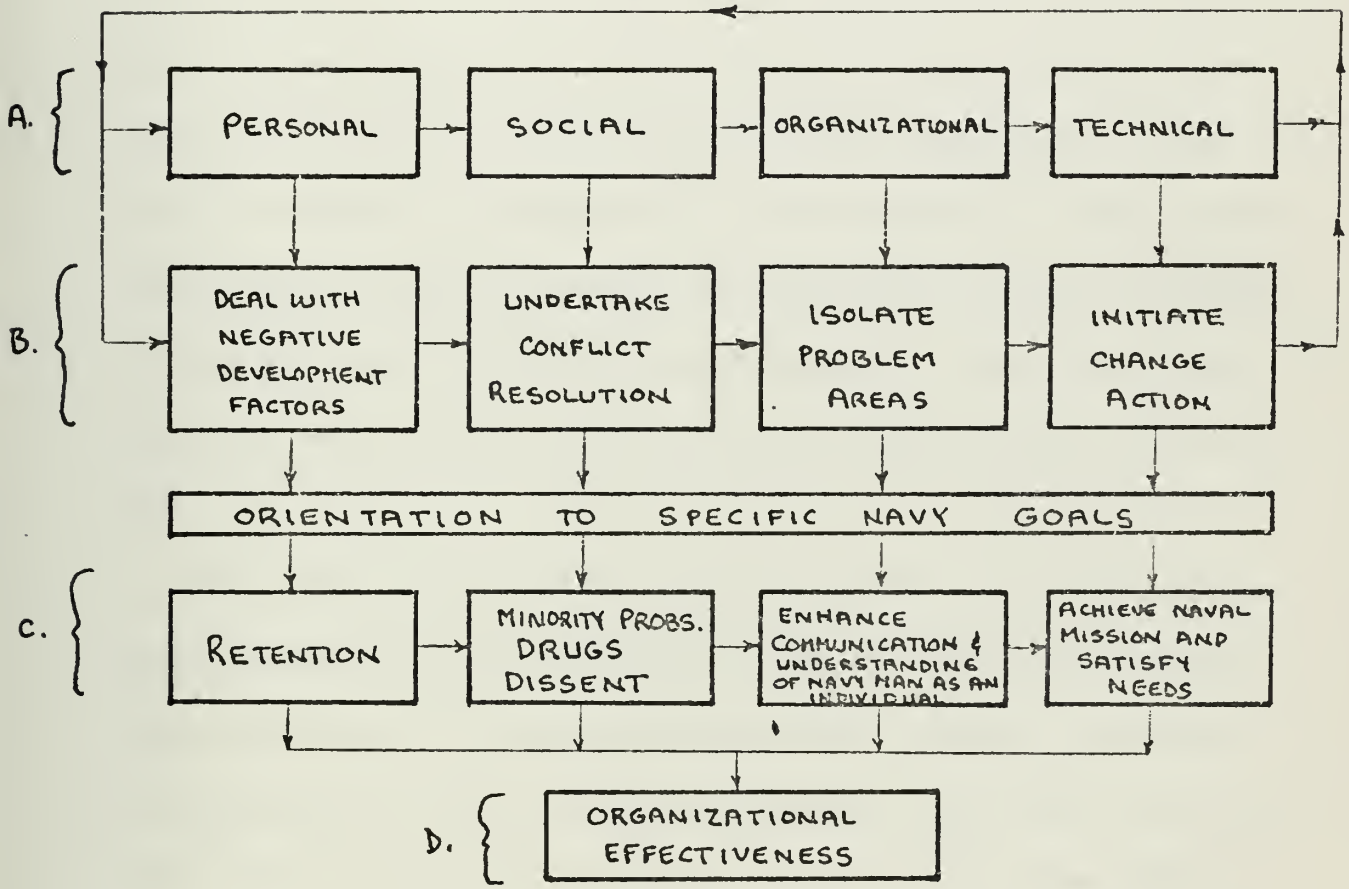


FIGURE 4.
CONTINUOUS ACTION SPECTRUM

Key:
A. FRAMES OF REFERENCE
B. COURSES OF ACTION
C. AREAS OF INTENDED IMPROVEMENT
D. GOAL

its proposed role. Once convinced of this capability, the HRMP must proceed to Stage II with primary concern for marketing its capability in order to justify its existence and gain acceptance.

B. MARKETING

The marketing function envisioned for the HRMP takes two approaches -- the marketing concept and marketing segmentation. The marketing concept emphasizes the HRMP's role in the satisfaction of client needs. Under this point of view, the four major functions of personal, social, organizational, and technical development are to be client-oriented and related to marketing efforts. As such, the marketing concept is integrative in nature; all activities of HRMP would be ultimately connected with the shaping and satisfaction of the client's desires. These efforts which would take place in a variety of organizational climates would be intended to "create and retain clients" and would be expected to lead, ultimately, to growth and effectiveness of the HRMP and the Navy as a whole.

The concept of market segmentation recognizes the diversity of client's needs and the assumption that different clients would respond differentially to various marketing approaches. As such, the concept is disaggregative in nature; HRMP (integrated, in the sense used above) would attempt to shape its marketing strategy so as to appeal differentially to the diversity of clients. In doing so, it is assumed that greater acceptance for the HRMP would result. This is the critical point in

Stage II in figure 1 that must be met before any wide-range application of the HRMP can be initiated. Problems will arise in the identification of the relative segments (distinguishing one type of client from another) and the prediction of consequences stemming from the employment of different approaches for different segments.

C. PERCEPTIONS AND PREFERENCES

It is from the dimensions of perceptions and preferences that attempted analysis and measurement of roles (the structure of human organization) is proposed. Analysis along these dimensions regarding potential HRMP services is congenial with both the marketing concept and market segmentation. First, client perception and preference scaling can provide operational measures of how the service is being seen and evaluated by the HRMP clients, actual or potential. Second, the fact that neither perceptions or preferences need be homogeneous over clients can suggest opportunities for segmentation strategy. As will be shown, perceptual and preference measurement can provide an operational procedure for implementing both concepts which is, in turn, seen to be critical to the major problems of role achievement and acceptance. The key is in the measurement.

C. MEASUREMENT

The naval organization is viewed as being in a continuous state of change. The conditions requiring these changes arise from within as well as from without. Quality of the decision-making process is

critical to effective change and depends upon sound decisions based on accurate information about the relevant dimensions of the organizational climate as well as valid interpretation of that information.

An analogy to the potential HRMP role in measurement is seen as one in which a doctor attempts to diagnose an illness. Two types of information are required to make a diagnosis. First, the nature of human beings must be explored through research relating symptoms to causes and measurements of body conditions to the health state of the organism. This can reveal the character of the human body's normal and abnormal functioning. Likert views this approach as one in which the organizational doctor is provided insight into how the human organizational system ought to function, so that he needs to know what he needs to measure and how he needs to interpret the measurements. He views the second type of information needed at any particular time as being that obtained by appropriate measurements and tests made on the patient at that time (5).

Basic information provided by whatever measurement technique employed should promote the understanding of the nature of the management system, the way in which its component parts function, and the adaptive responses (change) it makes to an altered environment. This basic knowledge is viewed as a prerequisite to the determination of what specific measurements should be made for diagnostic purposes and therapeutic measures.

III. QUALITATIVE MEASUREMENTS

The two kinds of information required initially regard the health state of the human organization and its symptomatic behavior. By health state, it is meant that data be collected in order to construct a conceptual model of the human organization. The long-range implications of the high level backing given such a program as the HRMP indicates it is thought of as an experiment to analyze the feasibility of a gradual intended shift to a more scientific-based management for a smaller, more professional, Navy of the future. Thus, health state measures could be used to evaluate various sectors of the current naval establishment in light of a science-based, organizational model, with qualities more similar to the organizational System 4 described by Likert.[1] This model, in turn, could suggest measurements potentially relevant for diagnostic purposes and how to interpret such data. Data on the symptomatic behavior would be extracted to reveal the functioning characteristics of the organization, such as leadership behavior, the character of motivation, communication, and decision-making. This is essentially the type of analysis that Likert has experimented with in his work. He submits that the various dimensions of the human organization and its operation

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[1] For a complete description of System 4 characteristics, a thorough reading of Likert's Human Organization (5) is required.

can be placed into a conceptual framework which contributes to their interpretation and helps guide decisions on what to measure. Such a framework focuses its attention on the key places to introduce change. These places (organizational variables) are grouped into three broad categories -- causal, intervening and end-result.

Causal variables are defined by two essential characteristics: (1) they can be changed by members of the organization since they are not fixed by external circumstances; (2) they are independent variables which, when changed, cause other variables to change. Intervening variables are produced largely by the causal variables and in turn have an influence upon the end-result variables. Considering the ordered cycle of causal, intervening and end-result variables, it has been generally observed that change is most effective when the variables are dealt with in order. In essence, this means that organization changes should parallel individual changes in order that the organization may accommodate to and make use of such changes in the individual.

The end-result variables reveal the final outcome and reflect the influence of the intervening variables upon them. With the previously mentioned objective of enhanced organizational effectiveness as an example, Figure 5 displays a scheme of variable interaction consistent with the problem setting described herein. A more specific attempt to build a construct of such relationships would be the first step in obtaining some type of profile of organizational characteristics. Analysis of such a profile would provide the health state "picture" and symptomatic

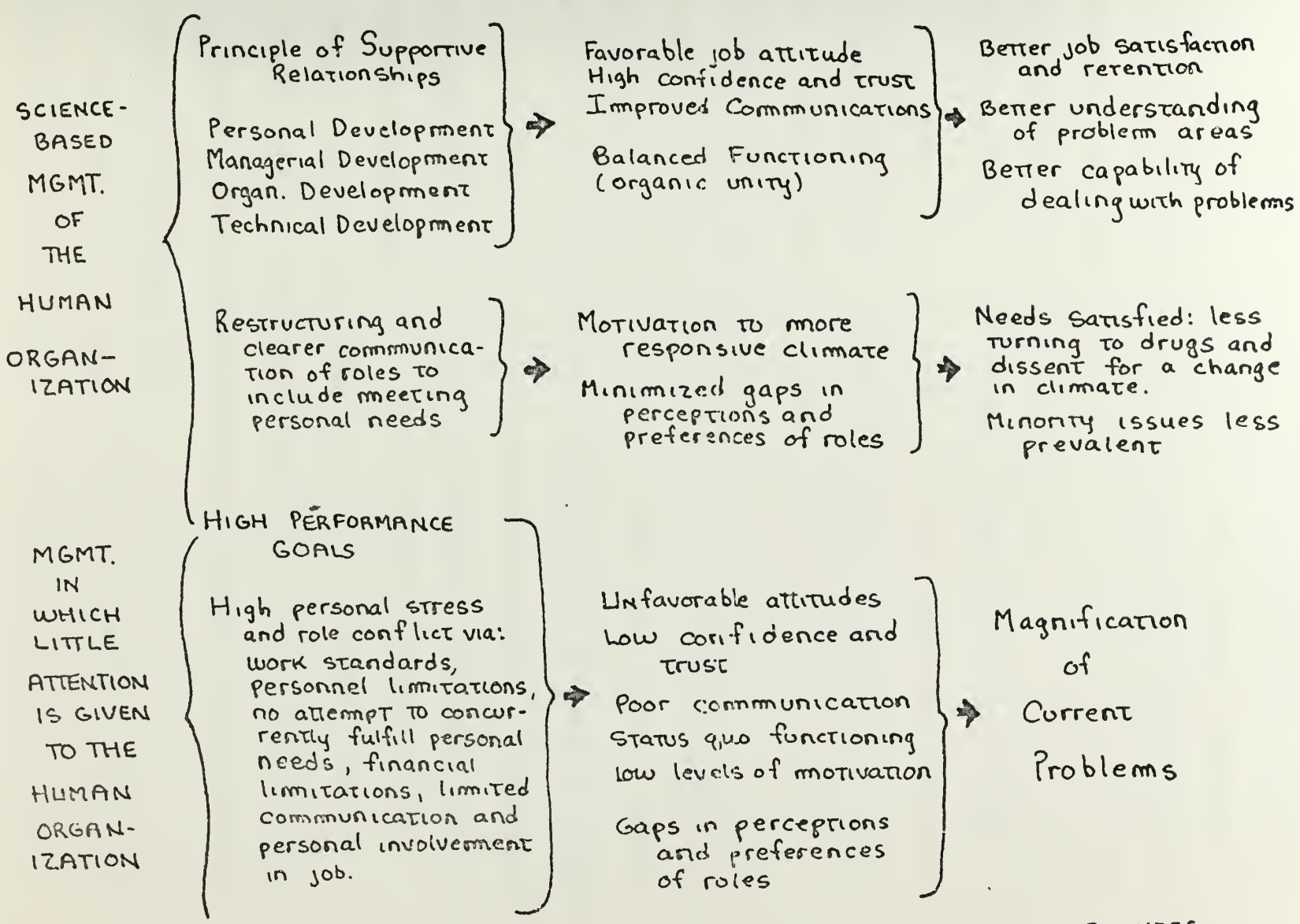


FIGURE 5. RELATIONSHIPS OF VARIABLE TYPES

relationships (first two levels of information) as are initially desired in the measurement process.

This is the Likert approach. Appendix A displays the output of this type of approach. Respondents are asked questions regarding various operating characteristics of the organization. One questionnaire is answered according to how such characteristics are perceived and another like questionnaire asks the same questions on a preferred basis. Questions are force-answered with sub-characteristic descriptions. The respondent rates each characteristic on a continuum according to the descriptions given. Appendix A displays the resulting profile of characteristics which are a combination of causal and intervening variables. The range over which the profile is constructed (in this case authoritative-participative management) is an end-result variable. The mean of the profile provides a general health state "picture" (i.e. it might show that the organization's management is basically participative, and this is "healthy" if that is the desired end result). Symptomatically, each characteristic can be rated "less healthy," "as healthy," or "more healthy" than the organization by the magnitude and direction of its standard deviation from the mean health state. From this general diagnosis can come action recommendations of a general nature such as "decision-making should be more participative," "lateral communication needs improving," etc.

More information can be derived from segmenting the classes of respondents (i.e. superiors vs. subordinates). Overlying profiles

from both segments can point out qualitative gaps in perception and preferences. Such gaps could suggest that efforts are needed (i. e. improved communication) to consider roles and needs at both levels and that the underlying cause for these gaps should be explored.

It is at this point that the current literature in social research has halted. While such information about symptoms is useful and an improvement over previous analysis practices, there is a distinct call for more specific information regarding the etiology (or causality) of symptomatic behavior. The Likert approach is deemed here to be the most useful tool available in providing health state and symptomatic information. As such it is suggested that his questionnaire (5) be administered as a "rough - cut" analysis and as a control technique.

Likert, himself, states that measurements and diagnoses of organizational ills are more complex than this. He is currently working on this problem. It is premised that the treatment of symptoms (intervening variables only) rather than causes (causal variables) can be costly to an organization in terms of physical and human assets. In asking why this etiological approach is not in use, it is pointed out that certain "truths" of medical diagnosis and treatment can apply equally to the diagnosis and treatment of organizational ills. It is easier to describe symptoms than to describe causal agents. It is easier to prescribe broad-spectrum treatments than to specify the exact therapeutic effects of any one. And, cures often occur without any clear indication of which therapeutic agent may have been most effective.

Behavioral prescriptions need to be known based upon knowledge of the causal agents underlying the symptoms of organizational ill health described previously. All this should be studied using more sophisticated measures of interpersonal perceptions and preferences. The quantitative approach to this end proposed in the next chapter is embryonic. It is envisioned that perhaps in 15 to 20 years from now techniques with similar objectives as the one proposed will be in active application. Such applications would outline specific behavioral outcomes to be expected in different organizational climates after exposure to particular behavioral prescriptions (i.e. specific personal, social, organizational, and technical development programs) carried out in response to carefully diagnosed organizational needs. The approach proposed is an attempt to lay the ground work for such an application.

IV. QUANTITATIVE MEASUREMENTS

A. MULTIDIMENSIONAL SCALING

Multidimensional scaling, an emerging tool in psychometrics and marketing strategy, is the proposed technique through which attempts will be made initially to study causality. This scaling method and related techniques are concerned primarily with the spatial representation of relationships among behavioral data -- in this case, respondent perceptions and preferences about organizational characteristics in a client organization. While a more technical description of multidimensional scaling is presented in Appendix B, the basic concepts are presented here at an intuitive and content-oriented level.

B. ATTRIBUTE SPACE

First, an organization is visualized as composed of both objective and perceived attributes or "dimensions." An organization may have an extensive audit by a consulting firm leading to an objective description of it in terms of its characteristics. Such objective attribute "spaces," in which various characteristics are viewed as points positioned somewhere in the space, will usually not agree with an organizational member's perceived space. The perceived space, in contrast, consists of characteristics which reflect the member's perception of the organization - those attributes (values) which he uses in making discrimination judgments among characteristics. Thus, a set of

organizational characteristics can be assumed to occupy positions in both objective and perceived space. The perceptual "maps" of characteristics may, of course, vary over individual perceivers and vary over time and context within the same individual. Moreover, the dimensionality of this space -- the "richness" of the typical perceptual map -- may vary over the classes of characteristics (types of organizational variables considered). From the viewpoint of etiology, the perceived dimensions are the relevant ones.

C. IDEAL POINTS

Individuals are also characterized as having an ideal stimulus in a subjective (perceived) attribute space. If so, what is the implication? One rather compelling implication is that individuals prefer some particular combination of values within the organization to all other existing values regarding mission and satisfaction of personal needs. In one formulation of this concept, characteristics "closer" to an individual's ideal point will tend to be preferred to those farther away (6). Moreover, the individual respondent may differentially weigh the values in terms of their relative importance to him. If such is the case, the distance between his perceived and preferred (ideal Point) responses to organizational characteristics is assumed to reflect the differential "stretching" which he applies to the values of interest.

As hopefully the reader might gather, the concept of attribute space is central to the proposed quantitative technique about to be

explained. Under some circumstances (specific organizational climates) the "nearness" of any two characteristics can be formulated as an operational measure of "healthful" functioning. Finally, respondents can be positioned in an evaluative attribute space as well (i.e. comparison made between responses from superiors and subordinates).

What is ultimately desired from this conceptualization, then, is a transformation which links selected distances in evaluative attribute space to the criticality of the characteristics (strategic organizational variables) deemed to cause the symptoms previously measured by Likert's approach. It is proposed that multidimensional scaling will provide such a transformation.

D. CONCEPTUAL APPROACH

An attempt is proposed here to map client perceptions and preferences of organizational characteristics (behavioral data). The major categories of characteristics are taken from Likert which are expressed as the following organizational variables:

- Leadership processes
- Motivational forces
- Communication processes
- Interaction-influence
- Decision-making processes
- Goal setting
- Control processes
- Performance goals and training

These behavioral components are subjected to client responses in the form of individual questionnaires. Perception and preference

responses are elicited in each of the below evaluative frames of reference:

- Personal Space, i.e., the frame of reference in which the individual thinks about himself.

- Social Space, i.e., the frame of reference in which the individual thinks about the groups of which he is a part.

- Organizational Space, i.e., the frame of reference in which the individual thinks about the organizational unit whose purposes he is serving.

- Technical Space, i.e., the frame of reference in which the individual thinks about the systematic knowledge and techniques appropriate to his work.

For example, over the range of the end-result variable of authoritative-participative management, the following questions might be asked in each frame of reference, or mental space, about the character of the decision-making process:

- Personal: To what extent are you involved in decisions relating to your work?

- Social: To what extent do you consult with other individuals and groups in making decisions affecting your group?

- Organizational: To what level in the organization do you look for formal approval of decisions made?

- Technical: What kind of information and analysis is required for the decision-making in which you are involved?

The purpose of eliciting responses in each of these four subjective spaces, or frames of reference, on each organizational variable is to determine whether the organizational variable in question is being handled in an "imbalanced" or "balanced" manner. This approach is based on two hypotheses:

1. Organizational variables can be dealt with in an imbalanced manner: (e.g. communications are dealt with technically with little concern for personal or social aspects of communication). This implies that giving attention to each evaluative space is important in the organization process.

2. Such imbalances are the most basic causes behind symptomatic behavior. (e.g. a technically "correct" communication may be personally unacceptable or in violation of social norms.)

The basic analysis proposed poses several questions:

- With regard to each variable, is there a particular disregard for any particular frame of reference?

- To what extent is one or more frames of reference being addressed or disregarded extensively through the organization as a whole?

- Are there patterned imbalances in certain variables and balanced attention in others? (i.e. is there an internal consistency from which characteristics are being viewed?)

The object is to look for a pattern of denial or emphasis in any evaluative space for any organizational variable. Such patterns are premised to be directly related to problems as retention and to be those which have the potential of an in-house "remedy". Surely, reducing these patterns of imbalance through the approach diagramed in Figure 2 is a more controllable and predictable therapeutic "remedy" than an attempt to change the external environment (social attitudes towards the military and pay limitations imposed by government).

Thus, initially, disorders should first be addressed along these in-house patterns of denial. Variables would be strategically ranked as to criticality according to the divergence patterns (imbalances) found. The mix of personal, social, organizational, and technical development

programs used would be such as to successively filter out the major problems in these areas until operational satisfaction is obtained.

E. APPLICATION

The first task is to select an end-result variable range over which perceptions and preferences will be judged. Some examples of possible ranges include:

-Authoritative-Participative Management

-Conflict Producing-Conflict Minimizing Management

-Innovative Producing-Innovative Inhibiting Management

-Need Satisfying-Non-Satisfying Management

The choice of the range would depend upon the particular organizational climate desired. As mentioned previously, different naval organizations each have a particular climate most conducive to their goals. For example, an operational destroyer division would be evaluated "better" in a climate in the authoritative-participative range, and a research and development facility would be better reviewed in an innovative climate.

The next task is to write questions in each evaluative space about each of the eight organizational variables listed. Thus, question category 1 would concern the leadership process. Questions 1a, 1b, 1c, and 1d would be from personal social, organizational, and technical perspectives respectively. For consistency, all "a" questions would be personal, "b" questions social, etc. Sub-descriptions would

be given for each to force answers in a general category along the continuum of the range. An example of such a questionnaire is given in Appendix C based on the authoritative-participative range. The respondent would mark his judgment for each variable somewhere on a continuum of 20 spaces. Approximately half of the question's scales would be reversed to eliminate bias toward any particular end of the range. It should be noted which scales are reversed so to line them up properly (all "1's" on the left side and all "20's" on the right) before analysis. It is noted that no numbers for these scales appear on the actual questionnaire. They are placed after the respondent has replied. The "1's" would imply very authoritative and the "20's" very participative.

When questionnaires are completed, these numbers (psychological distances) are tabulated and the mean for each question computed.

From this data, a Likert-type sociogram as shown in Appendix A can be constructed. These can be done both for the "perception" or "preference" type questionnaires and additionally segmented into respondent classes (i.e. top officers, junior officers, petty officers, enlisted). Interpretations such as explained for the Likert model earlier can be made and compared to those from the Likert questionnaire.

More importantly, however, "third level" or etiological analyses can at this point take place with the data obtained. The object will be to get "maps" of similarities in perceptions and preferences from the data. Taking two spaces at a time (i.e. all the "a" questions and "b" questions), mappings are constructed using the multidimensional

scaling program provided in Appendix D along with a "cookbook" explanation of how to use it. Looking at all possible combinations of four spaces taken two at a time provides six distinct two-dimensional mappings. Points plotted on these mappings are labeled according to the question number they represent.

From these mappings the answers to the questions posed in the conceptual approach are sought. Point groupings indicate similarity in perspective, thus, if the "a" questions were consistently plotted on the extremities, an initial conclusion could be drawn that there is a general disregard for the personal dimension when considering the organization as a whole. Similarly, if the "b" questions were not grouped with the other three in any particular variable, one could conclude that there is a general disregard for the social perspective in that particular variable. Next, one would look at the larger question as to whether or not there was an internal consistency from which the characteristics were being reviewed.

Since the spaces between the points plotted are Euclidean distances, an ordering can be made of all variables in each space in descending order of imbalance as determined by the "distances of disregard." This then, is the strategic variable list previously mentioned. For example, the variable order in which therapeutic effort might be prescribed could be the following:

- technical aspects of communication
- organizational aspects of control
- social aspects of decision-making
- personal aspects of motivation

From such a ranking of strategic variables (which zero in on the dimension of each variable in most imbalance), action programs could be designed specifically to filter problems in these areas successively until operational satisfaction is achieved. A general program for the above might include a consultive technical audit of communications from a civilian communications corporation, a structural organization study to analyze and make recommendations on control methods, laboratory training to explore the social aspects of decision-making, and reevaluation of job design to improve personal motivation. Thus, the multidimensional technique gets right to the initial phases of developing and initiating the desired action programs designed ultimately to improve the overall effectiveness of the Navy. An evaluative effort would be the last function to be performed in meeting the overall objective of the HRMP.

F. EVALUATION

At this point the proposed technique has been described as potentially providing information (including "third level" causality) to promote the understanding of the nature of a management system and the way in which its component parts function (i. e. in an imbalanced manner). Such information is to be thus applied in creating specific

organizational climates (altered environments) for specific segments of the Navy in which the accomplishment of the naval mission and the concurrent satisfaction of personal needs can be met.

This same technique is also designed to provide measures of the adaptive responses (change) it makes in these altered environments. Such an evaluative process takes place merely by administering the same questionnaires and performing the same mapping techniques at some point in time after therapeutic change has been induced. The degree to which a particular organization was in a state of balance or imbalance prior to any change action is deemed proportional to the elapsed time after which change measures would begin to appear. Such measures on the first two levels would be the qualitative shifts of the health state or particular symptoms over the end-result range profile. Narrowed gaps in perceptions and preferences at each level and among levels would also be another qualitative measure.

On the third level of causality, the "distances" by which perceptions and preference change can be measured in Euclidean space. Such numbers are still deemed to be subjective shifts in values. But these values, when referred to the particular situations to which they were addressed, are deemed to be a specific change measure in relation to the extent to which an organizational climate has improved in regard to its new state of "balance" or equilibria.

V. CONCLUSION

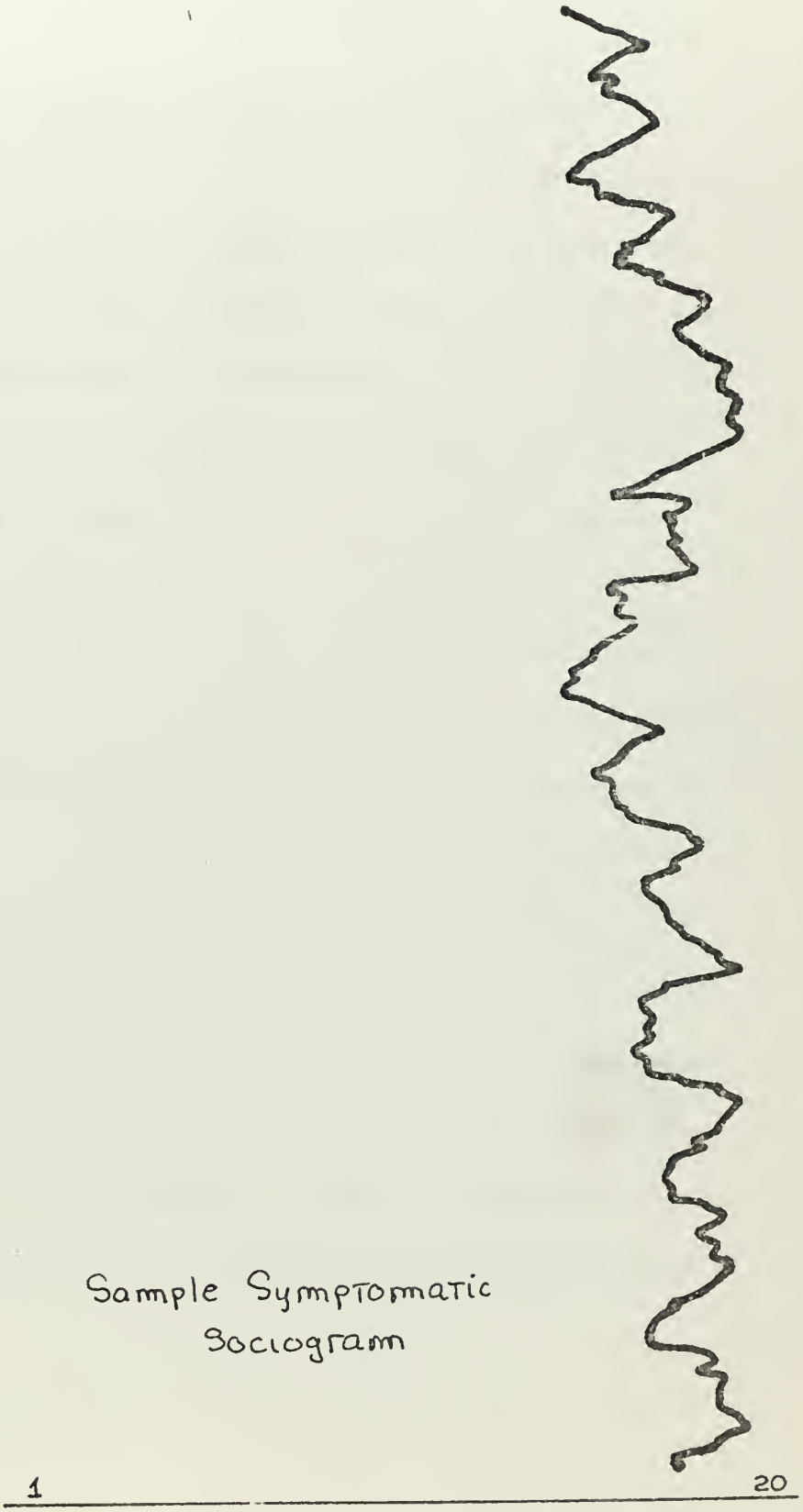
It is suggested that this "measurement" technique approaches the limits to which subjective information can be structured. The resultant information, if specific enough for cursory interpretations and conclusions, can be used both for meeting the envisioned objective functions of the HRMP and in marketing its capabilities for survival. It is deemed that the conceptual approach taken here is consistent with the goal for which the HRMP was designed. If the information provided is not specific enough on the "first cut," the approach is structured so that with slight modifications in technique (i.e. asking more specific questions in the questionnaire, using the Likert form "before and after" as a control technique, experimenting over more specific or more general end-result ranges, etc.) determination of more specific measurements can be made to meet the objective.

This is not to say that such techniques as the one proposed hold all the answers. As an end state, the perfectibility of the human organization must perhaps remain an article of faith; nonetheless, some of the elements necessary to give the perfectibility idea some credence have been found in research to date. These elements include an increased understanding of the human organization in systematic terms and a concurrent willingness to test that understanding by trial, experiment, and the scrutiny of research. It is in that spirit and in the hope of

contributing to that end that this thesis, with its proposed measurement technique, has been written.

APPENDIX A

Operating characteristics		System 1 Exploitive-- authoritative	System 2 Benevolent-- authoritative	System 3 Consultative	System 4 Participative group
Motivations	1a				
	b				
	c				
	d				
	e				
	f				
	g				
Communication	2a				
	b				
	c(1)				
	(2)				
	d(1)				
	(2)				
	(3)				
	(4)				
	(5)				
	e				
	f				
	(1)				
Interaction	3a				
	b				
	c(1)				
	(2)				
	d				
	e				
Decision making	4a				
	b				
	c				
	d				
	e(1)				
	(2)				
	f				
Goal setting	5a				
	b				
	c				
Control	6a				
	b				
	c				
	d				
Performance	7a				
	b				
	c				
	d				
Total					



Sample Symptomatic Sociogram

APPENDIX B

MULTIDIMENSIONAL SCALING*

Like all statistical techniques, multidimensional scaling is a method of summarizing and drawing inferences from a large body of data. In this case, the data are the judgments made by a respondent about the similarities or differences between stimuli presented in pairs. For N stimuli, multidimensional scaling attempts to find N points in a t dimensional mapping whose interpoint distances (N(N-1)/2 of them in all) somehow resemble or match the corresponding N(N-1)/2 similarity-dissimilarity judgments made by the respondent.

The importance of the number t stems from its interpretation as the number of dimensions on which the respondent based his judgments. The best method for determining this number when the investigator is using the multidimensional scaling techniques to be discussed in this paper has been given by Joseph B. Kruskal. (Kruskal, 1964a) His method assumes the capability to derive a mapping for any number of dimensions (one, two, three or more) and then involves a comparison of these mappings of different dimensionality. Since the question of how to derive a mapping for an arbitrary number of dimensions is the main topic of this paper, the dimensionality of the mapping which

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*From special abstract on this subject by James Capra, student, Naval Postgraduate School, 1970.

multidimensional scaling seeks to derive will be two throughout this paper. The techniques for deriving a mapping are the same whether the dimensionality is one, two, three or more. Also, the mapping will always be in Euclidean space. The contents of this paper can be adapted with very little trouble, however, to non-Euclidean spaces based on a city-block metric or a Minkowski r metric. (Kruskal, 1964a)

The discussion can be simplified by the use of an example. Suppose one is interested in identifying the dimensions of appeal of political candidates. What factors make some candidates attractive to a respondent and other candidates unattractive? For simplicity, suppose the investigator examines the feelings of one respondent with respect to four political candidates. Multidimensional scaling would help the investigator determine these factors or dimensions of appeal by providing him with a t (two in this case) dimensional mapping of the candidates. The mapping would be based on judgments made by the respondent about the similarities or differences between the candidates presented in pairs.

One method of eliciting the judgments of a respondent concerning the similarities or differences between candidates presented in pairs is to administer a simple questionnaire to him. A typical item in such a questionnaire might resemble the following:

> Please specify how similar or how different these two individuals are in their general appeal to you by circling one of the numbers, 1 through 9. If you circle number 1, it implies that they are exactly equal in their general appeal to you, while if you circle number 9, it implies that they are extremely different in their general appeal to you.

		Exactly Equal								Extremely Different
1.	Lyndon B. Johnson Hubert H. Humphrey	1	2	3	4	5	6	7	8	9

If the respondent's feelings toward four candidates were to be examined, he would be asked the same question about 5 other pairs of candidates, making a total of 6 questions in all.

The basic premise underlying the analysis of data from a questionnaire of this kind is that the numbers circled are measures of psychological distance, closeness or proximity between stimuli for the respondent. Shepard calls them proximity measures. (Shepard, 1962a) Here, however, they will be called psychological distances. These psychological distances will be labeled δ_{ij}'s, with the i referring to one stimulus and the j referring to the other. The investigator only obtains N(N-1)/2 judgments from the respondent since δ_{ij} equals δ_{ji} by assumption, and a special experimental design is required if δ_{ii} is to have any meaning. (If the assumption were dropped and the special design employed, the method of analysis would not change.) The formula N(N-1)/2 can be obtained by counting the elements in the lower triangular portion of an N by N matrix or by using the formula for the number of combinations of N objects taken two at a time, which is $\binom{N}{2}$ or N(N-1)/2.

A number of computer-based procedures for doing multidimensional scaling are currently available. (Shepard 1962, Kruskal 1964, Lingoes 1965) However, the discussion in this paper will be limited to the most

popular of these, the procedure proposed by Joseph B. Kruskal in 1964. In addition to being the most widely used, Kruskal's technique is the best vehicle for the introduction of a slightly different technique in this paper. For the most part, Kruskal's notation will be used in the analysis to follow.

To obtain interval proximity measures or psychological distances (δ_{ij}'s), one would need an experimental model somewhat different from the one outlined by Kruskal and used in this paper. For example, interval measures can be obtained by the "method of multidimensional rank order," the "method of complete triads," or a number of other methods. (Torgerson 1958) All of these methods are based on the law of comparative judgment. It should be noted, however, that even the law of comparative judgment does not yield δ_{ij}'s that are measurements on a ratio scale, a point that will become important later. (Thurstone 1920)

As mentioned earlier, the investigator has obtained N(N-1)/2 distance judgments from the respondent. Let M equal N(N-1)/2. These psychological distances, δ_{ij}'s, have a certain rank order:

$$\delta_{i_1 j_1} < \delta_{i_2 k_2} < \cdots < \delta_{i_m j_m} < \cdots < \delta_{i_M j_M} .$$

For example, a respondent might provide the following answers to a four candidate questionnaire:

$\delta_{12}=6$ $\delta_{14}=9$ $\delta_{34}=1$

$\delta_{13}=8$ $\delta_{24}=7$ $\delta_{23}=2$

This would mean that

$$\delta_{34}<\delta_{23}<\delta_{12}<\delta_{24}<\delta_{13}<\delta_{14}$$

Multidimensional scaling seeks to obtain a two (or t) dimensional mapping, called a configuration, of the stimuli for which the Euclidean (or non-Euclidean if they are desired) distances between the stimuli have the same rank order as the psychological distances, or δ_{ij}'s. This is the isomorphism which multidimensional scaling seeks to create between the psychological distances or proximity measures and the interpoint distances in a Euclidean mapping. Let X_i be a two dimensional vector, x_{i1} and x_{i2}, referring to the ith political candidate's position in the two dimensional mapping in Euclidean space. The Euclidean distance between the two candidates, i and j, is the square root of the sum of squares of the distances along each axis, or Pythagorean theorem,

$$d_{ij} = \sum_{t=1}^{2}(x_{it}-x_{jt})^2$$

In the four candidate example, the investigator would want to find a two dimensional mapping of the candidates for which $d_{34}\leq d_{23}\leq d_{12}\leq d_{24}\leq d_{13}\leq d_{14}$. The only fixed characteristics of the mapping are the relationships between the d_{ij}'s. The axes can be rotated in any direction and the origin placed anywhere. Kruskal places the origin at

the centroid of the configuration and normalizes the configuration by making the sum of the squared distances of the points from the origin equal one. Finally, he "normalizes the angular attitude of the configuration by rotating it so that its so-called principal axes coincide with the coordinate axes (in the natural order)."[1] The principal axes rotation is very important in the achievement of a solution for a different multidimensional scaling technique, that of Roger N. Shepard.[2] However, it is not important for solution purposes in the Kruskal technique, although it might help the investigator in the interpretation of his results.

Of course not all configurations of the points (particular mappings of the candidates) will yield d_{ij}'s that have the same rank order as the δ_{ij}'s. Consequently, what the investigator needs and what Kruskal provides is an index to determine how close a given configuration comes to satisfying the rank order requirements which the δ_{ij}'s place on the d_{ij}'s. This index is called stress.

Prior to defining stress, Kruskal introduces a new set of symbols, called $\hat{d}_{ij}$'s. The $\hat{d}_{ij}$'s are numbers which completely satisfy the rank order requirements given by the δ_{ij}'s. If the d_{ij}'s themselves satisfy

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[1]Kruskal, Joseph B., "Nonmetric Multidimensional Scaling: A Numerical Method," Psychometrika, v. 29, p. 120, June 1964.

[2]Shepard, Roger N., "The Analysis of Proximities: Multidimensional Scaling With an Unknown Distance Function," Psychometrika, v. 27, p. 132, June 1962.

these requirements, then the set of $\hat{d}_{ij}$'s could be, and in fact will be, identical to the set of d_{ij}'s. However, consider the following situation. The δ_{ij}'s are in the order specified in the example used earlier,

$$\delta_{34} < \delta_{23} < \delta_{12} < \delta_{24} < \delta_{13} < \delta_{14} \quad ,$$

and the mapping that has been obtained has the following d_{ij}'s:

$d_{34}=2$ $\quad$ $d_{12}=3$ $\quad$ $d_{13}=7$

$d_{23}=1$ $\quad$ $d_{24}=4$ $\quad$ $d_{14}=6$

The rank order of the d_{ij}'s is the following:

$$d_{23} \leq d_{34} \leq d_{12} \leq d_{24} \leq d_{14} \leq d_{13}$$

A set of numbers, $\hat{d}_{ij}$'s, that satisfy the rank order constraints set by the δ_{ij}'s can be obtained in the following way:

$\hat{d}_{34}=\hat{d}_{23}=(d_{34}+d_{23})/2=1.5$ $\quad$ $\hat{d}_{24}=d_{24}$

$\hat{d}_{12}=d_{12}$ $\quad$ $\hat{d}_{13}=\hat{d}_{14}=(d_{13}+d_{14})/2=6.5$,

so that $\hat{d}_{34} \leq \hat{d}_{23} \leq \hat{d}_{12} \leq \hat{d}_{24} \leq \hat{d}_{13} \leq \hat{d}_{14}$.

This example demonstrates that the $\hat{d}_{ij}$'s are based on <u>averages of certain d_{ij}'s</u>. In the example, so-called "equality blocks" (for lack of a better name) were created for $\hat{d}_{34}$ and $\hat{d}_{23}$ and for $\hat{d}_{13}$ and $\hat{d}_{14}$ by averaging d_{34} and d_{23} to find $\hat{d}_{34}(=\hat{d}_{23})$ and averaging d_{13} and d_{14} to find $\hat{d}_{13}(=\hat{d}_{14})$. The method of calculation of $\hat{d}_{ij}$'s for every situation is part of a technique called "monotone regression." (Miles 1959) Monotone regression is not discussed in any detail in this paper. However, one of its properties is that the differences between the d_{ij}'s and $\hat{d}_{ij}$'s computed in the example represent the minimum

differences between the distances, the d_{ij}'s, and any set of numbers satisfying the rank ordering specified by the δ_{ij}'s.

In the above paragraph the point was made that if the d_{ij}'s do not satisfy the rank order constraints, the $\hat{d}_{ij}$'s will be averages of certain d_{ij}'s, as seen in the example. If the problem has M distances, then it can be shown that there are $2^{M-1}-1$ possible ways to average the d_{ij}'s to obtain $\hat{d}_{ij}$'s; or, if the case under which each $\hat{d}_{ij}$ equals its respective d_{ij} is considered to be a degenerate type of averaging, then 2^{M-1} possible ways exist.[3]

Another example may help. Suppose the investigator is dealing with three stimuli and consequently with three distances: d_{12}, d_{13}, d_{23}. The psychological distances are in the following order: $\delta_{12}<\delta_{13}<\delta_{23}$. There are 2^{3-1} or 4 different ways to average d_{ij}'s to obtain $\hat{d}_{ij}$'s. First of all, each $\hat{d}_{ij}$ may be equal to its respective d_{ij}, or

$$(1) \qquad \begin{aligned} \hat{d}_{12} &= d_{12} \\ \hat{d}_{13} &= d_{13} \\ \hat{d}_{23} &= d_{23} \end{aligned} \quad .$$

Another possibility is that

$$(2) \qquad \begin{aligned} \hat{d}_{12} &= \hat{d}_{13} = (d_{12}+d_{13})/2 \\ \hat{d}_{23} &= d_{23} \end{aligned}$$

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[3]The proof of this statement is a lengthy one that must be performed inductively. Since the number 2^{M-1} is not crucial to this analysis, the proof will not be given here.

A third is that

$$(3) \qquad \begin{aligned} \hat{d}_{12} &= d_{12} \\ \hat{d}_{13} &= \hat{d}_{23} = (d_{13}+d_{23})/2 \end{aligned} \quad .$$

The final possibility is that

$$\hat{d}_{12} = \hat{d}_{13} = \hat{d}_{23} = (d_{12}+d_{13}+d_{23})/3 \quad .$$

Monotone regression would lead to one of the four specifications, depending on the order of the d_{ij}'s obtained from a particular mapping. For example, given that $\delta_{12} < \delta_{13} < \delta_{23}$, the second specification would be appropriate if

$$d_{12} > d_{13}$$

$$d_{12} \leq d_{23}$$

$$d_{13} < d_{23}$$

Each of the four specifications will be called a block equality system. In the fourth specification, the block equality is $\hat{d}_{12} = \hat{d}_{13} = \hat{d}_{23}$, by definition. In the third, $\hat{d}_{13}$ equals $\hat{d}_{23}$ by definition, while in the second specification, $\hat{d}_{12}$ equals $\hat{d}_{23}$ by definition. There are no defined equalities in the first specification.

Now that the method of obtaining the $\hat{d}_{ij}$'s from the d_{ij}'s has been outlined and the concept of a block equality system as a defined equality between $\hat{d}_{ij}$'s has been introduced, stress can be defined:

$$\text{Stress} = \sqrt{\frac{\sum_{m=1}^{M} (d_{i_m j_m} - \hat{d}_{i_m j_m})^2}{\sum_{m=1}^{M} d_{i_m j_m}^2}}$$

Nonlinear programming becomes relevant at this point since the problem is to find the points and their distances that do the following:

Minimize Stress

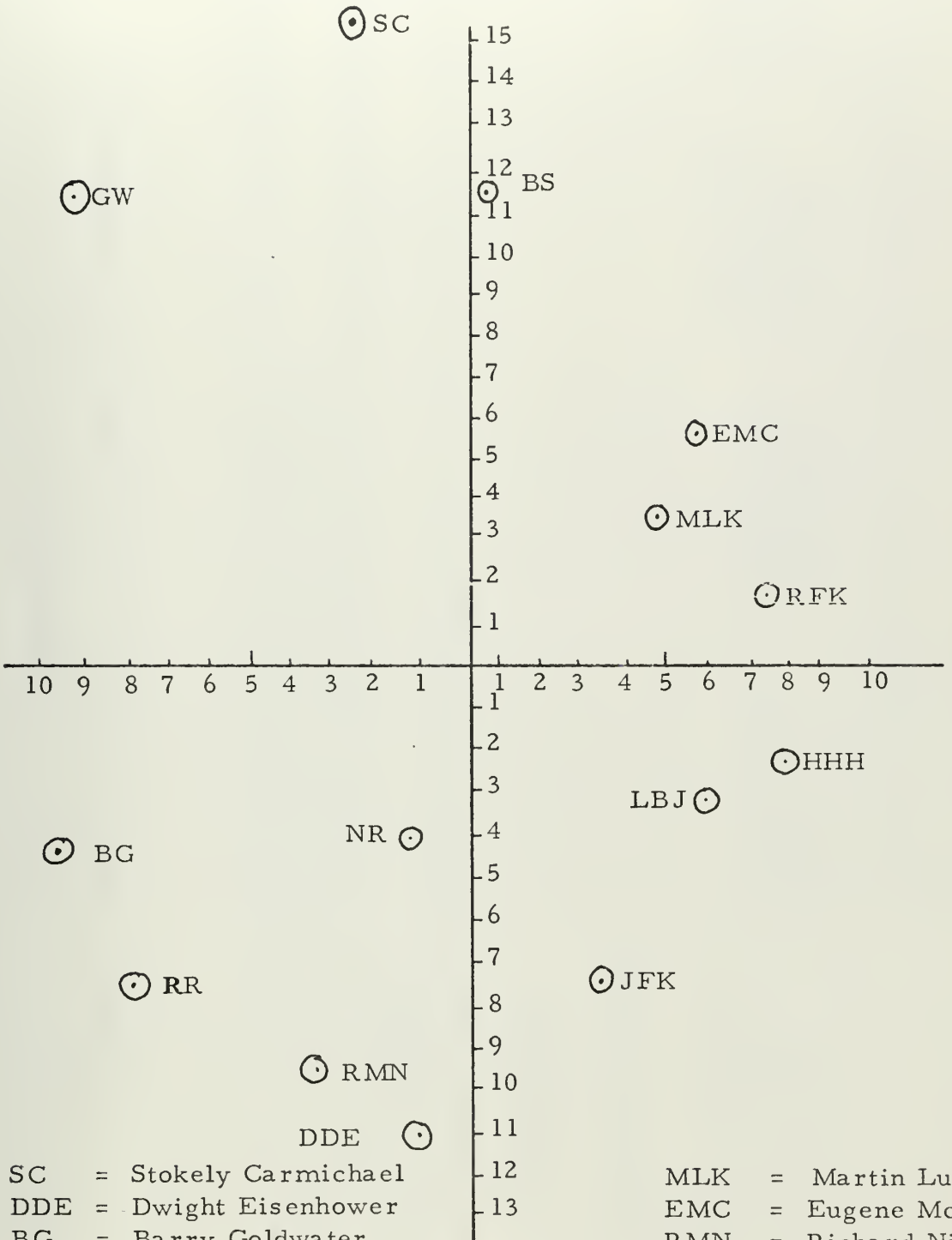
Subject to:

$$\hat{d}_{i_1 j_1} \leq \hat{d}_{i_2 j_2} \leq \ldots \leq \hat{d}_{i_m j_m} \leq \ldots \leq \hat{d}_{i_M j_M} .$$

Kruskal employs the "method of steepest descent" to solve this problem. (Kruskal 1964b) The heart of Kruskal's technique is the derivation of the points (the X's) in the mapping, and subsequently their distances. These provide the relationships this paper proposes.

Figure 8-1

A Euclidean Mapping of 14 Political Personalities
Obtained from Multidimensional Scaling



SC = Stokely Carmichael
DDE = Dwight Eisenhower
BG = Barry Goldwater
HHH = Hubert Humphrey
LBJ = Lyndon Johnson
JFK = John Kennedy
RFK = Robert Kennedy

MLK = Martin Luther King
EMC = Eugene McCarthy
RMN = Richard Nixon
RR = Ronald Reagan
NR = Nelson Rockefeller
BS = Dr. Benjamin Spock
GW = George Wallace

APPENDIX C

PROFILE OF ORGANIZATIONAL CHARACTERISTICS QUESTIONNAIRE

Instructions:

1. On the lines below each organizational variable (item), please place an n at the point which, in your experience, describes your organization at the present time (n = now). Treat each item as a continuous variable from the extreme at one end to that at the other.
2. In addition, if you have been in your organization one or more years, please also place a p on each line at the point which, in your experience, describes your organization as it was one to two years ago (p = previously).
3. If you were not in your organization one or more years ago, please check here ____ and answer as of the present time, i.e., answer only with an n.

Organizational variable

1. Leadership processes used

a. Extent to which you receive direction from more than one supervisor

From only one in your department | From two or three in your department | From several including one outside your department | From several, including more than one outside your department

b. Extent to which superiors behave so that subordinates feel free to discuss important things about their jobs with their immediate superior	Subordinates feel completely free to discuss things about the job with their superior	Subordinates feel rather free to discuss things about the job with their superior	Subordinates do not feel very free to discuss things about the job with their superior	Subordinates do not feel at all free to discuss things about the job with their superior
c. What is the span of control for supervisors	Two or three persons	Four or five persons	Six to ten persons	11 or as many as the individual supervisor seems capable of handling
d. Kind of leadership, knowledge, and training on which leadership practice is based in your organization	Constructive leadership based on traditional conservative, authoritarian assumptions	Basic traditional leadership with occasional responsiveness to upward influence	Tendency toward democratic practices based on acquired insights from experience	Group and person-centered leadership practices based on explicit training in behavioral science knowledge

2. Character of motivational forces

a. Satisfactions derived by you	Relatively high satisfaction throughout the organization with regard to membership in the organization, supervision and one's own achievements	Some dissatisfaction to moderately high satisfaction with regard to membership in the organization, supervision, and one's own achievements	Dissatisfaction to moderate satisfaction with regard to membership in the organization, supervision and one's own achievements	Usually dissatisfaction with membership in the organization, with supervision, and with one's own achievements

b.	Amount of responsibility felt by each member of organization for achieving organization's goals	Personnel at all levels feel real responsibility for organization's goals and behave in ways to implement them	Substantial proportion of personnel especially at higher levels, feel responsibility and generally behave in ways to achieve the organization's goals	Managerial personnel usually feel responsibility; rank and file usually feel relatively little responsibility for achieving organization's goals	High levels of management feel responsibility; lower levels feel little and often welcome opportunity to behave in ways to defeat organization's goals
c.	Kinds of attitudes developed toward organization and its goals	Attitudes are strongly favorable and provide powerful stimulation to behavior implementing organization's goals	Attitudes are favorable and support behavior implementing organization's goals	Attitudes are sometimes hostile and counter to organization's goals and are sometimes favorable to the organization's goals and support the behavior necessary to achieve them	Attitudes usually are hostile and counter to organization's goals

d.	Manner in which motives are used	Fear, threats, punishment, and occasional rewards	Rewards and some actual or potential punishment	Rewards, occasional punishment, and some involvement	Economic rewards based on compensation system developed through participation; group participation and involvement in setting goals, improving methods, appraising progress toward goals, etc.

3. Character of communication process

a.	How well does superior know and understand problems faced by you?	Knows and understands my problems very well	Knows and understands my problems quite well	He has some knowledge and understanding of my problems	Has no knowledge or understanding of my problems
b.	Psychological closeness of superiors to subordinates (i.e., friendliness between superiors and subordinates)	Usually very close	Fairly close	Can be moderately close if proper roles are kept	Far apart

c. Amount of interaction and communication aimed at achieving organization's objectives

Very little | Little | Quite a bit | Much with both individuals and groups

d. Extent to which superiors willingly share information with subordinates

Provide minimum of information | Gives subordinates only information superior feels they need | Gives information needed and answers most questions | Seeks to give subordinates all relevant information and all information they want

4. Character of interaction-influence process

a. Extent to which you feel you influence the goals, methods, and activity of your units and departments

Not at all, except through "informal organization" or via unionization | Little except through "informal organization" or via unionization | Moderate amount both directly and via unionization (where it exists) | Substantial amount both directly and via unionization (where it exists)

b. Amount of cooperative teamwork present

Very substantial | A moderate amount | Relatively little | None

c.	Extent to which an effective structure exists enabling one part of organization to exert influence upon other parts	Highly effective structure exists enabling exercise of influence in all directions	Moderately effective structure exists; influence exerted largely through vertical lines	Limited capacity exists; influence exerted largely via vertical lines and primarily downward	Effective structure virtually not present
d.	Amount of actual informational knowledge superiors use in determining the goals, activity, and methods of their units and departments	Believed to be substantial but actually moderate. No sharing of this information on which to make a judgment about it	Moderate to somewhat more than moderate. Little sharing of the information used	Moderate to substantial with considerable sharing of this knowledge	Substantial but always done with complete disclosure of the information and knowledge used
5.	Character of decision-making process				
a.	To what extent are you involved in decisions related to your work?	Not at all	Never involved in decisions; occasionally consulted	Usually are consulted but ordinarily not involved in the decision making	Are involved fully in all decisions related to their work
b.	To what extent are decision makers aware of problems, particularly those at lower levels in the organization?	Generally quite well aware of problems	Moderately aware of problems	Aware of some, unaware of others	Often are unaware or only partially aware

c. At what level in organization are decisions formally made?	Bulk of decisions at top of organization	Policy at top, many decisions within prescribed framework made at lower levels but usually checked with top before action	Broad policy decisions at top, more specific decisions at lower levels	Decision making widely done throughout organization, although well integrated through linking process provided by overlapping groups
d. How adequate and accurate is the information available for decision making at the place where the decisions are made?	Information is generally inadequate and inaccurate	Information is often somewhat inadequate and inaccurate	Reasonably adequate and accurate information available	Relatively complete and accurate information available based both on measurements and efficient flow of information in organization

6. Character of goal setting or ordering

a. Extent to which you are encouraged to participate in setting your own goals	Never	Sometimes	Frequently	Almost always

b.	Extent to which other departmental individuals and groups are involved in formulating a department's goals	Never	Sometimes	Frequently	Almost always
c.	To what extent do the different hierarchical levels tend to strive for high performance goals?	High goals sought by all levels, with lower levels sometimes pressing for higher goals than top levels	High goals sought by higher levels but with occasional resistance by lower levels	High goals sought by top and often resisted moderately by subordinates	High goals pressed by top, generally resisted by subordinates
d.	Extent to which technical goal-setting methods are used?	Strict use of technical goal-setting methods, i.e. use of balance sheet and performance data, etc.	Predominate use of technical methods with slight social application	Technical methods used as appropriate back up for jointly derived goals	Goal-setting essentially a social process involving mutual influence and shared commitments

7. Character of control processes

a. To what extent are you free to accomplish your assigned tasks in the manner you think best	Completely free to get job done in manner you think best	Usually free but with occasional direction	Sometimes free but usually follow specific directives	Never free. Specific directives always followed
b. Extent to which there is an informal organization present and supporting or opposing goals of formal organization	Informal organization present and opposing goals of formal organization	Informal organization usually present and partially resisting goals	Informal organization may be present and may either support or partially resist goals of formal organization	Informal and formal organization are one and the same; hence all social forces support efforts to achieve organization's goals
c. At which hierarchical levels in organization does major or primary concern exist with regard to performance of the control function?	At the very top only	Primarily or largely at the top	Primarily at the top but some shared feeling of responsibility felt at middle and to a lesser extent at lower levels	Concern for performance of control functions likely to be felt throughout organization

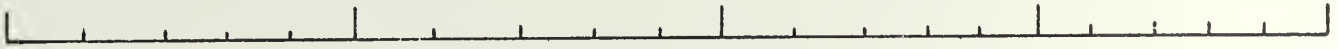
d.	How accurate are the measurements and information used to guide and perform the control function, and to what extent do forces exist in the organization to distort and falsify this information?	Strong pressures to obtain complete and accurate information to guide own behavior and behavior of own and related work groups; hence information and measurements tend to be complete and accurate	Some pressure to protect self and colleagues and hence some pressures to distort; information is only moderately complete and contains some inaccuracies	Fairly strong forces exist to distort and falsify; hence measurements and information are often incomplete and inaccurate	Very strong forces exist to distort and falsify; as a consequence, measurements and information are usually incomplete and often inaccurate

8. Performance goals and training

a.	Extent to which you have been given the kind of management training you desire	Have received no management training of kind I desire	Have received some management training of kind I desire	Have received quite a bit of management training of kind I desire	Have received a great deal of management training of kind I desire
b.	Extent to which you and others in your organization are encouraged to define your own performance goals and/or training needed to do the job	Always	Often	Seldom	Never

c. At what levels in the organization are performance goals and the need for training determined

Top only | Top with some input from middle managers | From the top down to supervisors | At all levels including individual participation



d. Adequacy of training resources provided to assist you in training your subordinates

Training resources provided are excellent | Training resources provided are very good | Training resources provided are good | Training resources provided are only fairly good

APPENDIX D

MECHANICS OF ANALYSIS

The procedure for analyzing data from a questionnaire such as in Appendix C is as follows:

1. Record the numbers of questions whose scales were reversed. Write in numbers from 1 to 20 under the blank scales on which responses were recorded.

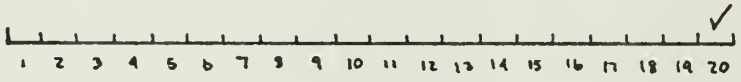
2. Calculate the mean of each question collectively and also for segmented groups (e.g. top managers, supervisors, etc.). Round off to nearest whole number.

Once this is completed, it is desired to compare the similarity/dissimilarity responses of each question to all others.

This is done by taking each possible pair of questions (496 in all) and asking the hypothetical question, for example

In regard to questions 1a and 3c, how similar or dissimar did you respond to them?

Exactly Similar ... Total Dissimilar



For example, if 1a were marked with a "1" and 3c with a "20" they were totally dissimilarly viewed. Thus box "20" would theoretically be marked . In general, the below matrix is given to arrive at this similarity/dissimilarity number. This is not normally considered proper when working with ordinal scales, but forcing responses along

the continuum with objective sub-descriptions helps to justify this simplification.

In other words, this matrix is consulted for each combination of two questions with a similarity/dissimilarity number resulting for each. These numbers are entered into a half matrix for tabulation. This matrix plus the dimensionality (in this case 4) are the inputs into the multidimensional scaling program. The same procedure is done for each group of type questions (i.e. for all the "a" and "b" questions only) of which there are six such combinations ("a's" with "b's", "a's" with "c's", "a's" with "d's", "b's" with "c's", "b's" with "d's", and "c's" with "d's"). Similar matrices are constructed and six two dimensional mappings (instead of one with four dimensions) are constructed from the scaling program.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
4				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
5					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
6						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7							1	2	3	4	5	6	7	8	9	10	11	12	13	14
8								1	2	3	4	5	6	7	8	9	10	11	12	13
9									1	2	3	4	5	6	7	8	9	10	11	12
10										1	2	3	4	5	6	7	8	9	10	11
11											1	2	3	4	5	6	7	8	9	10
12												1	2	3	4	5	6	7	8	9
13													1	2	3	4	5	6	7	8
14														1	2	3	4	5	6	7
15															1	2	3	4	5	6
16																1	2	3	4	5
17																	1	2	3	4
18																		1	2	3
19																			1	2
20																				1

COMPUTER OUTPUTS

1. Notes on interpretation:

   a. Output 1: A sample is shown for 14 questions in 3 dimensions. The coordinates of the mappings are labeled FINAL CONFIGURATION

   b. Output 2: A sample (with demographic question) is given where question numbers are tabulated according to demographic range, number responding, and number of responses to each of the spaces (8 as shown, 20 for this paper).

   c. Output 3: The sample provided shows the percentage response to each possible space and the resultant median response for each question.

COMPUTER PROGRAMS

Three programs are presented for possible use in performing the calculations mentioned. Program 1 is the main program (Kruskal's MDSCAL) through which the coordinates for the mappings result as output. Program 2 provides for tabulation of a questionnaire and Program 3 calculates the mean for each question.

1. Notes on Usage

   a. Program 1: Behind the source program place the following data cards as called for by the program.

```
1 DIMX = 4
1 DIMN = 4
1 DISSIMILARITIES
  NAME CARD
    32    1
  FORMAT CARD (in regards to final half matrix)
  DATA (in form of final half matrix)
1  COMPUTE
```

   b. Program 2: Question 38 in the sample is for demographic data (i.e. level in organization, years in organization, etc.). Such data would be obtained along with the questionnaire presented herein. The range of numbers 1 through 8 is the end-result range (in this case 20). In the program given, the numbers 15 and 80 would be changed to 32 as this is a program for general use.

   c. Program 3: Change 10 to 20 (range number) and 80 to 32 for use in this application

ERATION	STRESS	SRAT	SRATAV	CAGRGL	COSAV	ACSAV	SFGR	STEP
0	0.407	0.800	0.800	0.000	0.000	0.000	0.0208	0.4225
1	0.326	0.802	0.801	0.412	0.272	0.272	0.0227	0.5811
2	0.305	0.936	0.843	-0.626	-0.320	0.505	0.0224	0.2985
3	0.256	0.839	0.842	-0.003	-0.111	0.174	0.0117	0.2171
4	0.237	0.927	0.869	0.031	-0.017	0.079	0.0123	0.1798
5	0.227	0.954	0.897	-0.302	-0.206	0.227	0.0120	0.1146
6	0.215	0.951	0.914	0.168	0.041	0.188	0.0089	0.0881
7	0.205	0.953	0.927	0.747	0.507	0.557	0.0098	0.1374
8	0.185	0.903	0.919	0.808	0.706	0.723	0.0131	0.2889
9	0.141	0.758	0.862	0.252	0.406	0.412	0.0234	0.4167
10	0.156	1.110	0.938	-0.544	-0.221	0.499	0.0431	0.1948
11	0.077	0.494	0.757	0.250	0.090	0.334	0.0166	0.1396
12	0.072	0.941	0.814	-0.503	-0.301	0.446	0.0228	0.0803
13	0.063	0.876	0.834	-0.577	-0.484	0.533	0.0148	0.0366
14	0.060	0.941	0.868	-0.072	-0.212	0.229	0.0088	0.0244
15	0.058	0.967	0.900	0.338	0.151	0.301	0.0074	0.0226
16	0.056	0.974	0.924	0.296	0.247	0.298	0.0063	0.0250
17	0.055	0.984	0.944	-0.194	-0.044	0.229	0.0074	0.0158
18	0.055	0.987	0.958	-0.227	-0.165	0.227	0.0042	0.0091
19	0.054	0.994	0.970	0.352	0.177	0.310	0.0030	0.0077
20	0.054	0.996	0.978	0.592	0.451	0.496	0.0024	0.0101
21	0.054	0.996	0.984	0.137	0.244	0.259	0.0026	0.0102
22	0.054	1.000	0.989	-0.630	-0.333	0.504	0.0038	0.0039
23	0.054	0.997	0.992	0.891	0.475	0.759	0.0014	0.0042
24	0.054	0.999	0.995	-0.172	0.048	0.372	0.0014	0.0024
25	0.054	0.999	0.996	0.348	0.246	0.356	0.0008	0.0022
26	0.054	1.000	0.997	0.825	0.628	0.665	0.0007	0.0035
27	0.054	0.999	0.998	0.519	0.556	0.569	0.0007	0.0053
28	0.054	1.000	0.999	-0.506	-0.145	0.527	0.0020	0.0022
29	0.054	0.999	0.999	0.878	0.530	0.759	0.0006	0.0026
30	0.054	1.000	0.999	-0.513	-0.159	0.597	0.0010	0.0010
ERATION	STRESS	SRAT	SRATAV	CAGRGL	COSAV	ACSAV	SFGR	STEP

NIMUM WAS ACHIEVED

E FINAL CONFIGURATION OF 14 POINTS IN 3 DIMENSIONS HAS STRESS 0.054

NAL CONFIGURATION

1	2	3
0.512	0.179	-0.561
0.224	-0.607	-0.576
-0.278	-0.915	-0.092
0.372	0.637	-0.372
-0.785	-0.709	0.094
-0.474	0.770	1.044
0.640	-0.266	0.292
-0.478	-0.287	-0.551
-0.509	-0.615	0.630
-0.185	-0.975	-0.383
0.004	1.376	0.636
0.127	1.009	0.373
0.790	-0.099	0.010
0.040	0.501	-0.544

****

OUTPUT 1.

QUESTION 38 RESPONSES	NUMBER RESPONDING	QUESTION 1 RESPONSES							
		1	2	3	4	5	6	7	8
1	6	0	0	0	6	0	0	0	0
2	8	0	0	0	2	6	0	0	0
3	12	0	0	0	0	6	6	0	0
4	12	0	0	6	0	0	6	6	0
5	6	0	0	0	0	0	0	6	6
6	18	6	0	0	0	0	0	0	6
7	14	6	0	6	0	0	0	0	0
8	12	6	0	0	0	0	0	0	6
9	12	0	6	0	0	0	0	6	0
10	8	0	0	6	0	0	0	0	0

QUESTION 38 RESPONSES	NUMBER RESPONDING	QUESTION 2 RESPONSES							
		1	2	3	4	5	6	7	8
1	6	0	0	0	0	6	0	0	0
2	8	0	0	0	0	2	6	0	0
3	12	0	0	0	0	6	0	6	0
4	12	6	0	0	0	0	6	0	6
5	6	0	0	0	0	0	0	6	0
6	18	0	6	0	0	0	0	0	6
7	14	6	0	0	0	0	0	6	0
8	12	0	6	0	0	0	0	0	6
9	12	0	0	6	0	0	0	0	6
10	8	0	0	0	6	0	0	0	0

QUESTION 38 RESPONSES	NUMBER RESPONDING	QUESTION 3 RESPONSES							
		1	2	3	4	5	6	7	8
1	6	0	0	0	0	0	6	0	0
2	8	0	0	0	0	2	0	6	0
3	12	0	0	0	6	0	0	0	6
4	12	0	0	6	0	0	0	0	6
5	6	0	0	0	0	0	0	0	0
6	18	0	0	6	0	0	0	0	0
7	14	0	6	0	0	2	0	0	0
8	12	0	0	6	0	0	0	0	6
9	12	0	0	0	6	0	0	6	0
10	8	0	0	0	0	6	0	0	0

QUESTION 38 RESPONSES	NUMBER RESPONDING	QUESTION 4 RESPONSES							
		1	2	3	4	5	6	7	8
1	6	0	0	0	0	0	0	6	0
2	8	0	0	0	0	0	0	2	6
3	12	0	0	0	0	0	6	0	6
4	12	0	6	0	0	0	0	0	6
5	6	0	0	0	0	0	0	0	6
6	18	0	6	0	0	0	0	0	0
7	14	0	0	6	0	0	6	0	0
8	12	0	0	0	6	0	0	6	0
9	12	0	0	0	0	6	0	0	6
10	8	0	0	0	0	0	6	0	0

OUTPUT 2.

OUTPUT 3.

QUESTION	RESPONSE	NUMBER RESPONDING	PERCENT
1			
	1	12	11.11
	2	6	5.56
	3	18	16.67
	4	8	7.41
	5	6	5.56
	6	6	5.56
	7	6	5.56
	8	12	11.11
	9	24	22.22
	10	10	9.26
		108	
THE MEDIAN RESPONSE IS 6			
2			
	1	12	11.11
	2	12	11.11
	3	6	5.56
	4	6	5.56
	5	14	12.96
	6	6	5.56
	7	12	11.11
	8	18	16.67
	9	12	11.11
	10	10	9.26
		108	
THE MEDIAN RESPONSE IS 6			
3			
	1	6	5.56
	2	6	5.56
	3	24	22.22
	4	12	11.11
	5	10	9.26
	6	6	5.56
	7	12	11.11
	8	12	11.11
	9	12	11.11
	10	8	7.41
		108	
THE MEDIAN RESPONSE IS 5			
4			
	1	6	5.56
	2	12	11.11
	3	6	5.56
	4	6	5.56
	5	6	5.56
	6	18	16.67
	7	14	12.96
	8	22	20.37
	9	12	11.11
	10	8	7.41
		108	
THE MEDIAN RESPONSE IS 7			
5			
	1	12	11.32
	2	6	5.66
	3	8	7.55
	4	6	5.66
	5	24	22.64
	6	6	5.66
	7	12	11.32
	8	12	11.32
	9	12	11.32
	10	8	7.55
		106	
THE MEDIAN RESPONSE IS 5			
6			
	1	6	5.66
	2	8	7.55
	3	12	11.32
	4	18	16.98
	5	6	5.66
	6	12	11.32
	7	12	11.32
	8	20	18.87

FILE: MDS FORTRAN F1 **PROGRAM 1** CAMBRIDGE MONITOR

```
C     FORTRAN STAB,LSTOU                MDSCAL                MAIN PROGRAM
CMDSCAL ..... MDSCAL . MAIN PROGRAM
C MULTIDIMENSIONAL SCALING PROGRAM. KRUSKAL-LING. THIS VERSION MAY 196
C GENERAL REMARKS.
C THIS PROGRAM CONSISTS OF THE FOLLOWING ROUTINES.
C       MDSCAL   MAIN ROUTINE
C       FIT      PERFORMS WEIGHTED-LEAST-SQUARES REGRESSION.
C       NEWSTP   FINDS NEW STEP SIZE FOR ITERATIVE MINIMIZATION.
C       CCACT    READS AND INTERPRETS CONTROL CARDS.
C       SORT     SORTS ARRAYS. SIMPLE AND INEFFICIENT.
C ALL ARE WRITTEN IN FORTRAN IV.
C NO USE IS MADE OF SPECIAL OR NON-STANDARD SOFTWARE.
C ALL NORMAL INPUT-OUTPUT HANDLED BY  MDSCAL  AND  CCACT.
C FIT  HAS EMERGENCY DIAGNOSTIC OUTPUT.
C ALL INPUT AND OUTPUT IS ONTO THE TAPES WITH TAPE NUMBERS CONTROLLED
C THESE VARIABLES.  LREAD, LPRINT, LPUNCH, LSCRAT.
C TAPE NUMBERS 5, 6, 7, 8 HAVE BEEN USED RESPECTIVELY.
C TO CHANGE THESE ASSIGNMENTS, IT SUFFICES TO CHANGE THE VALUES
C FOR THE FOUR VARIABLES SET AT THE BEGINNING OF THE THREE ROUTINES.
C VALUES OF LREAD, LPRINT, LPUNCH, LSCRAT ARE DATA SET REFERENCE
C NUMBERS.  5,6,7,8 HAVE BEEN USED WHEN USING OS/360 MVT WITH CATALOG
C PROCEDURE FORTCLGO.  5, 6, AND 7 ARE STANDARD DATA SET REFERENCE
C NUMBERS FOR SYSIN, SYSOUT, AND SYSPUNCH.  JCL HAS BEEN ADDED TO
C PROVIDE SCRATCH SPACE ON THE DIRECT ACCESS DEVICE SYSDA.  THE DD
C NAME OF THIS DATA SET IS FT08F001 AND THE DATA SET REFERENCE NUMBER
C IS 8.
C NOTE THAT THE SCRATCH SPACE IS USED IN A VERY MINOR WAY.
C IT IS USED ONLY BY  CCACT
C MANY INSTALLATIONS WILL HAVE ALTERNATE METHODS OF DOING THE SAME THI
C       MDSCAL   THIS IS THE MAIN ROUTINE.
C       IT DIRECTLY USES FIT, NEWSTP, CCACT, SORT.

      DIMENSION   DATA(5000), IJ(5000), DIST(5000), DHAT(5000)
     DIMENSION   LBLOCK(5000),WW(5000)
      DIMENSION   X(60,10),  GR(60,10),  GL(60,10)
      DIMENSION   CTITLE(18), DTITLE(18), FMAT(18)

      COMMON  LDIMX, LDIMN, LDIMD, CUTOFF, STRMIN
      COMMON  SEGRMN, COSAVW, ACSAVW, IFIRST, MATSW
      COMMON  SDSWIT,  LCSWIT, LFITSW, P, NOIT
      COMMON  SRATST, LSCH, LPUNSW

      EXTERNAL                          WTRAN

      INTEGER TWO9, TWO18
```

```
      DATA     TWO9, TWO18 /512, 262144/
      DATA     LREAD, LPRINT, LPUNCH, LSCRAT /2,8,7,1/
C     INITIALIZE PARAMETERS
  100 LDIMX=2
      LDIMN=2
      LDIMD=1
      CUTOFF=0.0
      STPMIN=0.01
      SEGRMN=0.0
      COSAVW=0.66
      ACSAVW=0.66
      IFIRST=1
      MATSW=1
      SDSWIT=+1.0
      LCSWIT=1
      LFITSW=1
      R=2.0
      NOIT=50
      SRATST=0.999
      CONSW=0.0
      STRESS=1.0
      NREPL1=1
      LSCH=1
      LPUNSW=2
C     CONTROL CARD READ
 1000 LCSWIT=1
      CALL CCACT
      GO TO (1000, 1100, 1165, 1182, 1200, 2000, 9000 ), LCSWIT
C     DATA READ
 1100 READ (LREAD, 10) (DTITLE(K),K=1,18)
      WRITE (LPRINT, 14) (DTITLE(K),K=1,18)
      READ (LREAD, 12) N,NREPL2
      WRITE (LPRINT,13) N,NREPL2
      IF(NREPL2) 1104,1104,1103
 1103 NREPL1=NREPL2
      GO TO 1105
 1104 WRITE (LPRINT,14)
 1105 READ (LREAD, 10) (FMAT(K),K=1,18)
      MA=1
      M=1
      DO 1160 I=IFIRST,N
      GO TO (1110, 1120), MATSW
 1110 MB=MA+(N-1)*NREPL1
      GO TO 1130
 1120 MAA=MA
      DO 1125 ISUB=1,NREPL1
      MB=MAA+I-IFIRST
      READ(LREAD,FMAT)(DATA(MP),MP=MAA,MB)
 1125 MAA=MB+1
```

```
      GO TO 1135
 1130 READ                (LREAD, FMAT1 (DATA(MP),MP=MA,MB)
 1135 DO 1150 MP=MA,MB
      IF( DATA(MP)-CUTOFF ) 1150, 1150, 1140
 1140 DATA(M)=DATA(MP)
      J=((MP-MA)/NREPL1)+1
      IJ(M) = TWO9 * I + J
      M=M+1
 1150 CONTINUE
 1160 MA=M
      MM=M-1
      DO 1161 I=1,MM
 1161 WW(I)=1.0
      SUMW = FLOAT(MM)
      GO TO 1000

C     WEIGHTS READ

 1165 MA=1
      M=1
      SUMW = 0.0
      DO 1180 I=IFIRST,N
      GO TO (1167,1170),MATSW
 1167 MB=MA+(N*NREPL1)-1
      GO TO 1172
 1170 MAA=MA
      DO 1171 ISUB=1,NREPL1
      MB=MAA+I-IFIRST
      READ(LREAD,FMAT)(WW(MP),MP=MAA,MB)
 1171 MAA=MB+1
      GO TO 1174
 1172 READ                (LREAD,FMAT)(WW(MP),MP=MA,MB)
 1174 DO 1177 MP=MA,MB
      IF(WW(MP)) 1177,1177,1175
 1175 WW(M)=WW(MP)
      SUMW = SUMW + WW(M)
      M=M+1
 1177 CONTINUE
 1180 MA=M
      GO TO 1000

C     WEIGHT FORMATION BY WFUNCTION

 1182 SUMW = 0.0
      DO 1185 M=1,MM
      TEMP1=DATA(M)
      WW(M) = WTRAN(TEMP1)
      SUMW = SUMW + WW(M)
 1185 CONTINUE
      GO TO 1000

C     CONFIGURATION READ

 1200 CONSW=1.0
      READ                (LREAD, 10) (CTITLE(K),K=1,18)
```

```
      WRITE              (LPRINT, 14) (CTITLE(K),K=1,18)
      READ              (LREAD, 12) NCON, LDIMCO
      WRITE              (LPRINT, 13) NCON, LDIMCO
      READ              (LREAD, 14) (FMAT(K),K=1,18)
      DO 1210 I=1,NCON
 1210 READ              (LREAD, FMAT) (X(I,L),L=1,LDIMCO)
      GO TO 1000

C     SOME INPUT FORMATS

   10 FORMAT(18A4)
   11 FORMAT(1H0,18A4)
   12 FORMAT(24I3)
   13 FORMAT(1X,24I3)
   14 FORMAT(1X,18A4)
   15 FORMAT(20E4.0)
   16 FORMAT( 86H BECAUSE THE NUMBER OF REPLICATES HAS NOT BEEN SPECI
     1IED, IT IS ASSUMED TO BE 1.                    )

C     COMPUTATION                    **********************************

 2000 FN=FLOAT (N)
      SQRTN=SQRT (FN)
      LDIM=LDIMX
      CALL RFUNCT(0)

C     IF NO CONFIGURATION HAS BEEN READ IN, CREATE AN ARBITRARY
C     STARTING CONFIGURATION.

 2100 IF(CONSW) 9999, 2110, 2200
 2110 TEMP1=1.0
      DO 2130 I=1,N
      DO 2120 L=1,LDIMX
 2120 X(I,L)=0.0
      K= MOD (I-1,LDIM) +1
      X(I,K)=TEMP1
 2130 TEMP1=TEMP1+1.0

C     SORT DATA AND IJ AND WW.
C     ALSO RECORD BLOCKS OF EQUAL DATA VALUES.

 2200 CALL SORT(DATA(1),MM,IJ(1),WW(1),DUMMY,2,SDSWIT)

C          -SORT- WILL SORT THE MM ELEMNTS OF -DATA- IN ALGEBRAIC
C          ORDER, ASCENDING OR DESCENDING ACCORDING TO WHETHER
C          SDSWIT IS + OR -.
C          AT THE SAME TIME, THE ELEMENTS IN -IJ- AND IN -WW- WILL
C          REARRANGED IN EXACTLY THE SAME ORDER. THUS THE
C          CORRESPONDENCE BETWEEN THE ELEMENTS OF -DATA- AND -IJ-
C          AND -WW- IS PRESERVED.

      K=1
      MA=1
      DATA(MM+1)=DATA(MM)-SDSWIT
```

START HERE

```
      DO 2240 MB=1,MM
      IF(DATA(MB+1)-DATA(MB)) 2220, 2210, 2220
 2210 K=K+1
      GO TO 2240
 2220 DO 2230 M=MA,MB
 2230 IJ(M) = IJ(M) + TWO18 * K
      K=1
      MA=MB+1
 2240 CONTINUE

C     START COMPUTATION IN CURRENT DIMENSION

 2300 FLDIM=FLOAT (LDIM)
      ITNO=0
      COSAV=0.0
      SRATAV=0.9
      ACSAV=0.0

C     INITIALIZE GRADIENT
 2400 TEMP1=SORT (1.0/FLDIM)
      DO 2410 I=1,N
      DO 2410 L=1,LDIM
 2410 GR(I,L)=TEMP1
      SEGR=SORTN

C     PRINT HEADING FOR HISTORY OF COMPUTATION.

 2500 WRITE (LPRINT, 20) N, LDIM
      WRITE (LPRINT, 21)
      WRITE (LPRINT, 22)
   20 FORMAT(28HOHISTORY OF COMPUTATION. N= , I4, 12H, DIMENSION=, I3
   21 FORMAT(52HOITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV,
     1 16H    SEGP    STEP )
   22 FORMAT(1X)

C     START CURRENT ITERATION  ************************************

C     NORMALIZE CONFIGURATION, MOVE AND CLEAR GRADIENT.

 3000 TEMP1=0.0
      DO 3030 L=1,LDIM
      TEMP2=0.0
      DO 3010 I=1,N
 3010 TEMP2=TEMP2+X(I,L)
      TEMP2=TEMP2/FN
      DO 3020 I=1,N
      X(I,L)=X(I,L)-TEMP2
 3020 TEMP1=TEMP1+X(I,L)**2
 3030 CONTINUE
      TEMP1=SORT (FN/TEMP1)
      DO 3040 L=1,LDIM
      DO 3040 I=1,N
      X(I,L)=TEMP1*X(I,L)
      GL(I,L)=TEMP1*GP(I,L)
```

```
 3040  GR(I,L)=0.0
       SEGL=TEMP1*SEGR
C      COMPUTE DISTANCES AND FIND BEST-FITTING MONOTONE PSEUDO-DISTAN
       DBAR = 0.0
 3100  DO 3120 M=1,MM
       LTEMP1 = MOD(IJ(M),TWO18)
       I = LTEMP1/TWO9
       J = MOD(LTEMP1,TWO9)
       TEMP1=0.0
       DO 3110 L=1,LDIM
 3110  TEMP1=TEMP1+RPOWER (X(I,L)-X(J,L))
       DIST(M)=RROOT (TEMP1)
       DBAR=DBAR+DIST(M)*WW(M)
 3120  CONTINUE
       DBAR=DBAR/SUMW
C                 DBAS IS EITHER 0 OR DBAR ACCORDING TO WHETHER
C                 STRESS FORMULA 1 OR 2 IS BEING USED.
       DBAS = 0.0
       IF(LSCH.EQ.2) DBAS = DBAR
 3130  CALL FIT(DATA,II,DIST,DHAT,LBLOCK,WW,  MM,LFITSW)
C      CALCULATE U, T, AND STRESS
 3200  U=0.0
       T=0.0
       DO 3210 M=1,MM
       U=U+(DIST(M)-DHAT(M))**2*WW(M)
 3210  T=T+(DIST(M)-DBAS)**2*WW(M)
 3215  U=SQRT (U)
       TEMP1=T
       T=SQRT (T)
       STRLST=STRESS
       STRESS=U/T
C                 IF STRESS = 0.0, SKIP AHEAD
       IF(U) 3220, 3700, 3220
 3220  PUT=1.0/(U*T)
       UOT3=U/(TEMP1*T)
C      CALCULATE THE (NEGATIVE) GRADIENT
 3300  DO 3330 M=1,MM
       LTEMP1 = MOD(IJ(M),TWO18)
       I = LTEMP1/TWO9
       J = MOD(LTEMP1,TWO9)
       IF(I-J) 3305,3330,3305
 3305  FACTOR=UOT3*(DIST(M)-DBAS)-PUT*(DIST(M)-DHAT(M))
 3315  FACTOR=FACTOR/RMIPOW (DIST(M))
       DO 3320 L=1,LDIM
       TEMP1=FACTOR*RMIPOW(X(I,L)-X(J,L))*WW(M)
       GR(I,L)=GR(I,L)+TEMP1
 3320  GR(J,L)=GR(J,L)-TEMP1
 3330  CONTINUE
```

```
C       FIND SCALE FACTOR OF GRADIENT, AND ANGLE-COSINE BETWEEN GRADI
C       AND PREVIOUS GRADIENT.

 3400   SEGR=0.0
        CAGRGL=0.0
        DO 3410 I=1,N
        DO 3410 L=1,LDIM
        SEGR=SEGR+GR(I,L)**2
 3410   CAGRGL=CAGRGL+GR(I,L)*GL(I,L)
        SEGR=SQRT (SEGR/FN)
C               IF GRADIENT = 0.0, SKIP AHEAD.
        IF(SEGR) 3420,3700,3420
 3420   TEMP1=SEGR*SEGL*FN
        CAGRGL=CAGRGL/TEMP1

C       STEP SIZE CALCULATIONS

 3500   IF(ITNO) 9999, 3510, 3520
 3510   SRAT=0.8
        GO TO 3530
 3520   SRAT=STRESS/STPLST
 3530   CALL        NEWSTP( STEP, ITNO, SEGR, STRESS,
     1  CAGRGL, COSAV, ACSAV, COSAVW, ACSAVW, SRAT, SRATAV )

C       PRINT CURRENT STATUS OF COMPUTATION

 3700   WRITE                (LPRINT,30)  ITNO,STRESS,SRAT,SRATAV,CAGRGL,
     1  COSAV,ACSAV,SEGR,        STEP
   30   FORMAT(I10,F7.3,F7.3,F7.3,F7.3,F7.3,F7.3,F8.4,    F8.4)

C       DECIDE WHETHER TO CONTINUE ITERATING

 3800   IF(STRESS) 9999, 3840, 3810
 3810   IF(SEGR-SEGRMN) 3850, 3850, 3815
 3815   TEMP1 = 0.5 * (1.0+SPATST)
        TEMP2 = 1.0 - TEMP1
        IF( ABS (SRAT-TEMP1) - TEMP2 ) 3816, 3816, 3820
 3816   IF( ABS (SRATAV-TEMP1) - TEMP2 ) 3850, 3850, 3820
 3820   IF(STRESS-STRMIN) 3860, 3860, 3830
 3830   IF(ITNO-NOIT) 3800, 3870, 9999
 3840   WRITE                (LPRINT, 21)
        WRITE                (LPRINT, 31)
   31   FORMAT(24H0STRESS WAS REACHED )
        GO TO 4000
 3850   WRITE                (LPRINT, 21)
        WRITE                (LPRINT, 32)
   32   FORMAT(21H0MINIMUM WAS ACHIEVED )
        GO TO 4000
 3860   WRITE                (LPRINT, 21)
        WRITE                (LPRINT, 33)
   33   FORMAT(32H0SATISFACTORY STRESS WAS REACHED )
        GO TO 4000
 3870   WRITE                (LPRINT, 21)
        WRITE                (LPRINT, 34)
   34   FORMAT(39H0MAXIMUM NUMBER OF ITERATIONS WERE USED )
```

```
      GO TO 4000
C     CONTINUE ITERATING
 3900 ITNO=ITNO+1
      TEMP1=STEP/SEGR
      DO 3910 I=1,N
      DO 3910 L=1,LDIM
 3910 X(I,L)=X(I,L)+TEMP1*GR(I,L)
      GO TO 3000
C     STOP ITERATING
 4000 WRITE (LPRINT, 40)N,LDIM,STRESS,(L,L=1,LDIM)
   40 FORMAT(27HOTHE FINAL CONFIGURATION OF,I4,
     1 10H POINTS IN,I3, 22H DIMENSIONS HAS STRESS,F7.3
     2 /1X/20H FINAL CONFIGURATION/1017)
      IF(LPUNSW.EQ.2) GO TO 4005
      WRITE (LPUNCH, 41)(DTITLE(I),I=1,18),N,LDIM
   41 FORMAT(13HCONFIGURATION/12A4/2I3/11H(2X,10F7.3) )
 4005 DO 4010 I=1,N
      WRITE (LPRINT, 42)I,(X(I,L),L=1,LDIM)
      IF(LPUNSW.EQ.2) GO TO 4010
      WRITE (LPUNCH, 43)I,(X(I,L),L=1,LDIM)
 4010 CONTINUE
   42 FORMAT(1X,I2,10F7.3)
   43 FORMAT(I2,10F7.3)
      WRITE (LPRINT, 44)
   44 FORMAT(10HO********** )
C
C                IF YOUR INSTALLATION HAS AUTOMATIC PLOTTING OR PICTURE
C                DRAWING EQUIPMENT, IT IS DESIRABLE TO INSERT HERE THE
C                NECESSARY PROGRAMMING TO OBTAIN A GRAPH OF BOTH DIST A
C                DHAT VERSUS DATA.  ALSO DESIRABLE IS A PLOT OF THE POI
C                IN THE CONFIGURATION (IN TWO DIMENSIONS).
C     CHANGE DIMENSION
 4100 LDIM=LDIM-LDIMD
      IF(LDIM-LDIMN)4110,2300,2300
 4110 WRITE (LPRINT, 45)
   45 FORMAT(50HO**************************************************** )
      GO TO 100
C               REINITIALIZE, AND RETURN FOR MORE INPUT.
C     NORMAL TERMINATION, AFTER READING -STOP- ONCONTROL CARD
 9000 STOP
C     TROUBLE EXIT
 9999 WRITE (LPRINT, 99)
   99 FORMAT(52HOKRUSKAL. IMPOSSIBLE BRANCH TAKEN FROM IF STATEMENT.
      STOP
```

```
FILE: MDS      FORTRAN  P1                                    CAMBRIDGE  MONITOR
      END
C     FORTRAN
CFIT                  FIT  FOR MDSCAL          FIT                FOR MDSCAL
      SUBROUTINE FIT(DATA,IJ,DIST,DHAT,LBLOCK,WW,  MM,LFITSW)
C     FIT    PERFORMS WEIGHTED-LEAST-SQUARES MONOTONE REGRESSION
C     THIS ROUTINE FINDS THE VALUES FOR  DHAT  WHICH ARE MONOTONIC
C     AND WHICH BEST APPROXIMATE  THE VALUES OF  DIST,
C     IN THE SENSE THAT THE SUM OF THE SQUARED DEVIATIONS,
C     EACH ONE WEIGHTED BY THE CORRESPONDING VALUE IN  WW ,
C     IS A MINIMUM.
C     IT DIRECTLY USES  SORT.

      DIMENSION  DATA(1800), IJ(1800), DIST(1800), DHAT(1800)
      DIMENSION LBLOCK(1800),WW(1800)
      INTEGER TWO9, TWO18

      DATA    LREAD, LPRINT, LPUNCH, LSCRAT      /2,8,7,1/

      DATA    TWO9, TWO18  /512,  262144/

C     FORM FIRST APPROXIMATION TO CORRECT PARTITON

C                 IF LFITSW=1,  USE PRIMARY APPROACH.  THUS WE SORT EACH
C                 BLOCK OF EQUAL VALUES OF DATA ACCORDING TO DIST VALUES
C                 THEN WE CREATE PARTITON INTO BLOCKS OF SIZE 1 TO START

C                 IF LFITSW=2,  USE SECONDARY APPROACH. THUS WE START W
C                 PARTITION INTO BLOCKS OF EQUAL DATA VALUES.

C                 WITHIN EACH BLOCK, OF WHATEVER SIZE, THE FIRST DHAT VA
C     GIVES THE WEIGHTED TOTAL OF THE DIST VALUES IN THAT BLOCK, WHIL
C                 THE LAST DHAT VALUE GIVES THE SUM OF THE WEIGHTS FOR T
C                 BLOCK.  SIMILARLY, WITHIN EACH BLOCK, THE FIRST LBLOCK
C                 VALUE AND THE LAST LBLOCK VALUE BOTH GIVE THE SIZE OF T
C                 BLOCK.
C     BLOCKS OF SIZE 1 FORM A PARTIAL EXCEPTION. EVERYTHIN IS THE SA
C                 EXCEPT THAT THE SUM OF THE W VALUES IS NOT FOUND IN THE
C                 LAST DHAT VALUE IN THE BLOCK.

  100 MA=1
  110 K = IJ(MA) / TWO18
      MB=MA+K-1
      GO TO ( 200, 300 ), LFITSW

C                 PRIMARY APPROACH

  200 IF(K-1) 9999, 220, 210
C                 IF K=1, SAVE SORTING TIME
  210 CALL SORT(DIST(MA),K,IJ(MA),DATA(MA),WW(MA),3,+1.0)

C                 -SORT- WILL SORT THE K ELEMENTS OF -DIST- IN ALGEBRAIC
C                 ORDER.
C                 BECAUSE THE FINAL ARGUMENT IS ZERO, SORTING WILL BE
```

```
C                ASCENDING OR DESCENDING ACCORDING TO THE VALUE OF
C                SUPPLIED DURING THE CALL FOR SORT IN MDSCAL.
C                THE ELEMENTS OF -II- AND -DATA- WILL BE REARRANGED
C       ALSO THE ELEMENTS OF -WW-,
  220   DO 230 M=MA,MB
        DHAT(M) = DIST(M) * WW(M)
  230   LBLOCK(M)=1
        GO TO 400
C                SECONDARY APPROACH
  300   LBLOCK(MA)=K
        LBLOCK(MB)=K
        TEMP1=0.0
        TEMP2 = 0.0
        DO 310 M=MA,MB
        TEMP1 = TEMP1 + DIST(M) * WW(M)
        TEMP2 = TEMP2 + WW(M)
  310   CONTINUE
        DHAT(MA)=TEMP1
        IF(K-1) 9999, 400, 320
  320   DHAT(MB) = TEMP2
C               PROCEED TO NEXT BOCK. QUERY. IS IT THE LAST
  400   MA=MA+K
        IF(MA-MM-1) 110, 500, 9999
C       START MAIN COMPUTATION  ********************************
  500   MA=1
  510   LUD=2
        NSATIS=0
  520   K=LBLOCK(MA)
        MB=MA+K-1
        IF(K-1) 9999, 530, 540
  530   WT =WW(MB)
        GO TO 550
  540   WT = DHAT(MB)
  550   DAV = DHAT(MA) / WT
        GO TO ( 600, 700 ), LUD
C               IS BLOCK DOWN-SATISFIED. IF NOT, MERGE
  600   IF(MA-1) 9999, 630, 610
  610   MBD=MA-1
        KD=LBLOCK(MBD)
        MAD=MBD-KD+1
        IF(KD-1) 9999, 613, 615
  613   WTD =WW(MBD)
        GO TO 617
  615   WTD = DHAT(MBD)
  617   DAVD = DHAT(MAD) / WTD
```

```
      IF( DAVD-DAV ) 630, 620, 620
  620 KNEW=K+KD
      LBLOCK(MAD)=KNEW
      LBLOCK(MB)=KNEW
      DTONEW = DHAT(MAD) + DHAT(MA)
      DHAT(MAD) = DTONEW
      DHAT(MB) = WT + WTD
      NSATIS=0
      MA=MAD
      GO TO 800
  630 NSATIS=NSATIS+1
      GO TO 800

C               IS BLOCK UP-SATISFIED. IF NOT, MERGE

  700 IF(MB-MM) 710, 730, 9999
  710 MAU=MB+1
      KU=LBLOCK(MAU)
      MBU=MAU+KU-1
      IF(KU-1) 9999, 713, 715
  713 WTU =WW(MBU)
      GO TO 717
  715 WTU = DHAT(MBU)
  717 DAVU = DHAT(MAU) / WTU
      IF( DAV-DAVU ) 730, 720, 720
  720 KNEW=K+KU
      LBLOCK(MA)=KNEW
      LBLOCK(MBU)=KNEW
      DTONEW = DHAT(MA) + DHAT(MAU)
      DHAT(MA) = DTONEW
      DHAT(MBU) = WT + WTU
      NSATIS=0
      GO TO 800
  730 NSATIS=NSATIS+1
      GO TO 800

C               PROCEED TO NEXT BLOCK IF READY.

  800 LUD = 3-LUD
C               QUERY. IS BLOCK BOTH UP AND DOWN SATISFIED. IF NOT, R
      IF(NSATIS-1) 820, 820, 810
C               QUERY. IS THIS LAST BLOCK. IF NOT, GO ON TO NEXT BLOC
  810 IF(MB-MM) 820, 900, 9999
  820 MA=MB+1
      GO TO 510

C     MAIN COMPUTATION COMPLETE. PLACE ANSWERS IN DHAT.

  900 MA=1
  910 K=LBLOCK(MA)
      MB=MA+K-1
      IF(K-1) 9999, 940, 920
  920 TEMP1 = DHAT(MA) / DHAT(MB)
      DO 930 M=MA,MB
  930 DHAT(M)=TEMP1
```

```
      GO TO 945
  940 DHAT(MA) = DIST(MA)
  945 MA = MB + 1
      IF(MA-MM-1) 910, 950, 9999
  950 RETURN

C     TROUBLE EXIT

 9999 WRITE (LPRINT, 99)
   99 FORMAT(50HOKRUSKAL. IMPOSSIBLE BRANCH TAKEN ON IF STATEMENT.
      STOP

      END

C     FORTRAN                    NEWSTP        FOR MDSCAL
CNEWSTP              NEWSTP  FOR MDSCAL
      SUBROUTINE NEWSTP( STEP, ITNO, SFGR, STRESS,
     1 CAGRGL, COSAV, ACSAV, COSAVW, ACSAVW, SRAT, SRATAV )

C     NEWSTP  THIS SUBROUTINE COMPUTES THE STEP SIZE.

C             THE MAIN PURPOSE OF THIS ROUTINE IS TO COMPUTE THE N
C             VALUE OF -STEP-.
C             INCIDENTALLY, IT UPDATES -COSAV-, -ACSAV-, AND -SRAT

C     UPDATE THREE AVERAGE QUANTITIES

      COSAV = CAGRGL*COSAVW  +  COSAV*(1.0-COSAVW)
      ACSAV = ABS (CAGRGL)*ACSAVW  +  ACSAV*(1.0-ACSAVW)
      SRATAV = (SRAT**0.33334)  *  (SRATAV**0.66666)
      IF(ITNO) 100, 100, 200

C             GUESS INITIAL STEP SIZE

  100 STEP= (50.0*STRESS) * SFGR
      RETURN

C             FIND NEW STEP SIZE

  200 ANG=4.0**COSAV
      TEMP1 = 1.0 + (AMIN1 (1.0,SRATAV) ) ** 5
      TEMP2 = 1.0 + ( ACSAV - ABS (COSAV) )
      BIAS = 1.4 / (TEMP1*TEMP2)
      GOODLK = SQRT (AMIN1 (1.0,SRAT) )
      STEP = STEP * ANG * BIAS * GOODLK
      RETURN
      END

C     FORTRAN                    REUNCT        FOR MDSCAL
CREUNCT              REUNCT  FOR MDSCAL
      FUNCTION REUNCT(RR)

      INTEGER RTYPE

      R=RR
```

```
      RTYPE=3
      IF(R.EQ.1.0)RTYPE=1
      IF(R.EQ.2.0)RTYPE=2
      RM1=R-1.0
      RECR=1.0/R
      RETURN

      ENTRY RPOWER(XX)

      X=XX
      GOTO(110,120,130),RTYPE
  110 RFUNCT=ABS(X)
      RETURN
  120 RFUNCT=X*X
      RETURN
  130 RFUNCT=ABS(X)**R
      RETURN

      ENTRY RM1POW(YY)
      Y=YY
      GOTO(210,220,230),RTYPE
  210 RFUNCT=0.0
      IF(Y.NE. 0.0) RFUNCT = SIGN(1.0,Y)
      RETURN
  220 RFUNCT=Y
      RETURN
  230 RFUNCT=SIGN(ABS(Y)**RM1,Y)
      RETURN

      ENTRY RROOT(ZZ)
      Z=ZZ
      GOTO(310,320,330),RTYPE
  310 RFUNCT=Z
      RETURN
  320 RFUNCT=SQRT(Z)
      RETURN
  330 RFUNCT=Z**RECR
      RETURN

      END

C     FORTRAN STAB,LSTOU          CCACT          FOR MDSCAL
  CCCACT                CCACT  FOR MDSCAL
      SUBROUTINE CCACT

      INTEGER                              LPAR(   25 )
      REAL                                  PAR(   25 )
      EQUIVALENCE              (LPAR,PAR)
      COMMON             LPAR
      INTEGER     TAB(4,30)
      REAL       ATAB(4,30)

      EQUIVALENCE                                (TAB,ATAB)

      REAL    C(73),WORD(5)
```

```
      REAL CHTAB(13)
      REAL BLANK, DOT
      INTEGER LTEMP
      INTEGER BLSW,NUMSW,DECSW,TYPE,XTYPE,T,TA, PARNO, TABNO
      DATA LREAD, LPRINT, LPUNCH, LSCRAT /2,8,7,1/
      DATA BLANK, DOT, EQUALS, COMMA, C(73) /1H ,1H.,1H=,1H,,1H
     DATA CHTAB/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H.,1H+,1H-
      DATA MTAB1A, MTAB1B, MTAB2A, MTAB2B /1,27, 28,29/
      DATA TAB(1,1),TAB(2,1),TAB(3,1),TAB(4,1) / 'DIMX',1,1,0/
      DATA TAB(1,2),TAB(2,2),TAB(3,2),TAB(4,2) / 'DIMN',1,2,0/
      DATA TAB(1,3),TAB(2,3),TAB(3,3),TAB(4,3) / 'DIMD',1,3,0/
      DATA TAB(1,4),TAB(2,4),TAB(3,4),TAB(4,4) / 'CUTO',2,4,0/
      DATA TAB(1,5),TAB(2,5),TAB(3,5),TAB(4,5) / 'STRM',2,5,0/
      DATA TAB(1,6),TAB(2,6),TAB(3,6),TAB(4,6) / 'SEGR',2,6,0/
      DATA TAB(1,7),TAB(2,7),TAB(3,7),TAB(4,7) / 'COSA',2,7,0/
      DATA TAB(1,8),TAB(2,8),TAB(3,8),TAB(4,8) / 'ACSA',2,8,0/
      DATA TAB(1,9),TAB(2,9),TAB(3,9),TAB(4,9) / 'DIAG',3,0,0/
      DATA TAB(1,10),TAB(2,10),TAB(3,10),TAB(4,10) / 'MATR',6,10,1/
      DATA TAB(1,11),TAB(2,11),TAB(3,11),TAB(4,11) / 'HALF',6,10,2/
      DATA TAB(1,12),TAB(2,12),TAB(3,12),TAB(4,12) / 'DISS',4,12,2/
      DATA TAB(1,13),TAB(2,13),TAB(3,13),TAB(4,13) / 'SIMI',5,12,2/
      DATA TAB(1,14),TAB(2,14),TAB(3,14),TAB(4,14) / 'CONF',6,12,5/
      DATA TAB(1,15),TAB(2,15),TAB(3,15),TAB(4,15) / 'COMP',6,12,6/
      DATA TAB(1,16),TAB(2,16),TAB(3,16),TAB(4,16) / 'PRIM',6,13,1/
      DATA TAB(1,17),TAB(2,17),TAB(3,17),TAB(4,17) / 'SECO',6,13,2/
      DATA TAB(1,18),TAB(2,18),TAB(3,18),TAB(4,18) / '0   ',1,14,0/
      DATA TAB(1,19),TAB(2,19),TAB(3,19),TAB(4,19) / 'ITER',1,15,0/
      DATA TAB(1,20),TAB(2,20),TAB(3,20),TAB(4,20) / 'SRAT',2,16,0/
      DATA TAB(1,21),TAB(2,21),TAB(3,21),TAB(4,21) / 'STOP',6,12,7/
      DATA TAB(1,22),TAB(2,22),TAB(3,22),TAB(4,22) / 'WEIG',6,12,3/
      DATA TAB(1,23),TAB(2,23),TAB(3,23),TAB(4,23) / 'WEIN',6,12,4/
      DATA TAB(1,24),TAB(2,24),TAB(3,24),TAB(4,24) / 'SEQ1',6,17,1/
      DATA TAB(1,25),TAB(2,25),TAB(3,25),TAB(4,25) / 'SEQ2',6,17,2/
      DATA TAB(1,26),TAB(2,26),TAB(3,26),TAB(4,26) / 'CAPD',6,18,1/
      DATA TAB(1,27),TAB(2,27),TAB(3,27),TAB(4,27) / 'NOCA',6,18,2/
      DATA TAB(1,28),TAB(2,28),TAB(3,28),TAB(4,28) / 'PRES',6,9,1/
      DATA TAB(1,29),TAB(2,29),TAB(3,29),TAB(4,29) / 'ABSE',6,9,2/
      DATA TAB(1,30),TAB(2,30),TAB(3,30),TAB(4,30) / 1,      2, 3,/

    1 FORMAT(72A1)
    2 FORMAT(1X,I1)
    3 FORMAT(1X,18A4)
    4 FORMAT(1X,I20)
    5 FORMAT(1X,F18.3)
    6 FORMAT(1X,72A1)
    9 FORMAT(51H MDSCAL DIAGNOSTIC. CONTROL CARD ABOVE IS IMPROPER.)
   10 FORMAT('1',72A1)
```

```
C       READ AND PRINT CONTROL CARD
  100   READ (LREAD,1) (C(I),I=1,72)
        WRITE(LPRINT,10) (C(I),I=1,72)
C       ANALYZE CONTROL CARD INTO TOKENS
C               EACH -TOKEN- IS DELIMITED BY BLANKS
C               THERE ARE THREE TYPES OF TOKENS.
C               ALPHABETIC, INTEGER, DECIMAL
C               ALPHABETIC UNLESS FIRST CHARACTER IS DIGIT OR DEC POI
C               DECIMALS.       DISTINGUISHED BY DECIMAL POINT
        REWIND LSCRAT
        BLSW=1
        NUMSW=1
        DECSW=1
        K=0

        DO 300 I=1,73

        X=C(I)
        GO TO (110,120), BLSW

  110   IF(X.EQ.BLANK .OR. X.EQ.EQUALS .OR. X.EQ. COMMA ) GO TO
        BLSW=2
        JA=I
      DO 115 KX=1,13
  115 IF(X.EQ.CHTAB(KX)) NUMSW=2
        IF(X.EQ.DOT) DECSW=2
        GO TO 300

  120   IF(X.EQ.BLANK .OR. X.EQ.EQUALS .OR. X.EQ. COMMA ) GO TO
        IF(X.EQ.DOT) DECSW=2
        GO TO 300

  130   K=K+1
        JB = MIND (I-1,JA+16)
        JC=20-(JB-JA+1)
        TYPE=1
        IF(NUMSW.EQ.2) TYPE=NUMSW+DECSW-1

        WRITE (LSCRAT,2) TYPE
        GO TO (140,150),NUMSW
  140   WRITE (LSCRAT,6) (C(J),J=JA,JB), (BLANK,J=1,JC)
        GO TO 160
  150   WRITE (LSCRAT,6) (BLANK,J=1,JC), (C(J),J=JA,JB)
        GO TO 160
  160   BLSW=1
        NUMSW=1
        DECSW=1
        GO TO 300

  300   CONTINUE

C       ANALYZE TOKENS AND SET PARAMETER VALUES ACCORDINGLY
```

```
      KB=K
      IF(KB.EQ.0) RETURN
      REWIND LSCRAT
      XTYPE=1
      TABNO=1

      DO 1000 K=1,KB

      READ (LSCRAT,2) TYPE
      IF(TYPE.NE.XTYPE) GO TO 999
      GO TO (400,410,420), XTYPE
  400 READ (LSCRAT,3) (WORD(L),L=1,5)
      GO TO (510,520), TABNO
  410 READ (LSCRAT,4) INTPAR
      LPAR(PARNO)=INTPAR
      GO TO 430

  420 READ (LSCRAT,5) DECPAR
      PAR(PARNO)=DECPAR

  430 XTYPE=1
      GO TO 1000

  510 MA = MTAB1A
      MB = MTAB1B
      GO TO 550
  520 MA = MTAB2A
      MB = MTAB2B
      GO TO 550

  550 DO 560 M=MA,MB
      M7=M
      IF(WORD(1).EQ.ATAB(1,M)) GO TO 600
  560 CONTINUE
      GO TO 999

  600 XTYPE=1
      TABNO=1
      PARNO=TAB(3,M7)
      LTEMP=TAB(2,M7)
      GO TO (610,620,630,640,650,660), LTEMP
C
  610 NAME OF INTEGER PARAMETER
      XTYPE=2
      GO TO 1000
C
  620 NAME OF DECIMAL PARAMETER
      XTYPE=3
      GO TO 1000
C
  630 -DIAGONAL-
      TABNO=2
```

```
      GO TO 1000
C     -DISSIMILARITIES-
  640 PAR(11) = 1.0
      GO TO 660
C     -SIMILARITIES-
  650 PAR(11) = -1.0
      GO TO 660
C     IMPLICITLY SPECIFIED PARAMETER
  660 LPAR(PARNO)=TAB(4,M7)
      GO TO 1000
 1000 CONTINUE
 1001 RETURN
  999 WRITE (6,9)
      STOP
      END
C     FORTRAN                    SORT          FOR  MDSCAL
CSORT                SORT  FOR MDSCAL
      SUBROUTINE SORT( A, N, B, C, D, K, SWITCH )
C     SORT    THIS SUBROUTINE SORTS ARRAY A, AND MAY REARRANGE B AN
C     THE N VALUES FROM A(1) TO A(N) ARE SORTED IN ALGEBRAIC ORDER.
C     IF SWITCH IS +, ASCENDING ORDER.
C     IF SWITCH IS -, DESCENDING ORDER.
C     IF SWITCH IS 0, ACCORDING TO LAST NON-ZERO VALUE OF SWITCH.
C     IF K=0, NEITHER OF ARRAYS B AND C IS TOUCHED.
C     IF K=1, ARRAY B IS REARRANGED.
C     IF K=2, ARRAYS B AND C ARE BOTH REARRANGED.
C     IF K=3, ARRAYS B AND C AND D ARE ALL REARRANGED.
C     REARANGING OF ARRAYS B, C, D IS IN ACCORDANCE WITH THE
C     REARRANGEMENT OF A DURING SORTING, SO THAT CORRESPONDING ENTR
C     IN THE ARRAYS CONTINUE TO OCCUPY CORRESPONDING POSITIONS.
      DIMENSION A(1800), B(1800), C(1800), D(1800)
      IF(SWITCH) 100, 105, 100
  100 SW=SWITCH
  105 KP1=K+1
      NM1=N-1
      IF(NM1) 300, 300, 107
  107 DO 150 I=1,NM1
      IP1=I+1
      DO 140 J=IP1,N
      IF( A(I)-A(J) ) 140, 140, 110
  110 TEMP=A(I)
```

```
      A(I)=A(J)
      A(J)=TEMP
      GO TO ( 140, 130, 120, 115), KP1
  115 TEMP = D(I)
      D(I) = D(J)
      D(J) = TEMP
  120 TEMP=C(I)
      C(I)=C(J)
      C(J)=TEMP
  130 TEMP=B(I)
      B(I)=B(J)
      B(J)=TEMP
  140 CONTINUE
  150 CONTINUE

      IF(SW) 200, 300, 300

  200 NHALF=N/2
      DO 230 I=1,NHALF
      IC=N+1-I
      TEMP=A(I)
      A(I)=A(IC)
      A(IC)=TEMP
      GO TO ( 230, 220, 210, 205 ), KP1
  205 TEMP = D(I)
      D(I) = D(IC)
      D(IC) = TEMP
  210 TEMP=C(I)
      C(I)=C(IC)
      C(IC)=TEMP
  220 TEMP=B(I)
      B(I)=B(IC)
      B(IC)=TEMP
  230 CONTINUE

  300 RETURN
      END

C     FORTRAN
CWTRAN      WTRAN  FOR MOSCAL          WTRAN          FOR  MOSCAL
      FUNCTION WTRAN(XX)
C     **********************************************************
C     THIS VERSION OF WTRAN IS STRICTLY A DUMMY VERSION
C     THE ONLY TIME WTRAN EVER GETS CALLED IS IF THE WEIINCTION OPTION
C     IS USED.
C     IF THIS OPTION IS INTENDED, IT IS NECCESSARY FOR THE USER TO WRI
C     HIS OWN VERSION OF WTRAN AND SUBSTITUTE IT FOR THIS ONE.
C     THIS VERSION MERELY PRINTS A SUITABLE REMARK AND STOPS.
      WTRAN = 1.0
      WRITE (6,1)
      STOP
```

```
1      FORMAT(46H **$**$**$**$**$**$**$**$**$**$**$**$**$**$**$**$
     1 57H MDSCAL DIAGNOSTIC. YOU ARE USING THE WFUNCTION OPTION OF /
     2 57HMDSCAL, BUT HAVE FAILED TO PROVIDE YOUR OWN WTRAN PROGRAM
     3 53H  **$**$**$**$**$**$**$**$**$**$**$**$**$**$**$**$**$**$)
       END
```

PROGRAM 2

```
VEL  18                    MAIN                    DATE = 71159          06/32/18
      DIMENSION NANSR(80),N(15,10),NA(15,10,80,10),NSKIP(80)
      CALL REREAD
      DO 130 I=38,49
      DO 130 J=1,10
      N(I,J)=0
      DO 130 K=1,80
      DO 130 L=1,10
      NA(I,J,K,L)=0
130   CONTINUE
      DATA IB/' '/
169   READ(5,100,END=95) (NANSR(I),I=1,80)
      DO 140 I=1,80
      NSKIP(I)=999
      IF(NANSR(I).NE.IB) GO TO 140
      NSKIP(I)=I
140   CONTINUE
      READ(99,100) (NANSR(I),I=1,80)
      DO 10 I=38,49
      IF(NSKIP(I).EQ.I) GO TO 10
      NANS=NANSR(I)
      IF(NANS.EQ.0) NANS=10
      DO 20 J=1,10
      IF(NANS.NE.J) GO TO 20
      N(I,J)=N(I,J)+1
      DO 30 K=1,80
      IF(I.EQ.K) GO TO 30
      IF(NSKIP(K).EQ.K) GO TO 30
      NANSA=NANSR(K)
      IF(NANSA.EQ.0)NANSA=10
      DO 40 L=1,10
      IF(NANSA.NE.L) GO TO 40
      NA(I,J,K,L)=NA(I,J,K,L)+1

I=DEMO QUESTION NUMBER  J=RESPONSE TO DEMO QUESTION  K= OTHER QUESTION N
 L=RESPONSE TO OTHER QUESTION
40    CONTINUE
30    CONTINUE
20    CONTINUE
10    CONTINUE
      GO TO 69
95    DO 70 I=38,49
      WRITE(6,102) I
      DO 80 K=1,80
      IF(I.EQ.K) GO TO 80
      WRITE(6,103) I,K
      WRITE(6,104)
      WRITE(6,105)
      DO 90 J=1,10
      WRITE(6,106) J,N(I,J)
      WRITE(6,107) (NA(I,J,K,L),L=1,10)
90    CONTINUE
80    CONTINUE
70    CONTINUE
100   FORMAT(80A1)
102   FORMAT(80I1)
103   FORMAT('1','THE FOLLOWING TABULATION RELATES THE ANSWERS TO EVERY
     1QUESTION TO THE ANSWERS GIVEN TO QUESTION ',I2)
104   FORMAT(//,3X,'QUESTION ',I2,4X,'NUMBER',10X,'**********************
     1***  QUESTION ',I2,'  RESPONSES  **********************')
105   FORMAT(' ',4X,'RESPONSES  RESPONDING',10X,'1',7X,'2',7X,'3',7X,'4
     1',7X,'5',7X,'6',7X,'7',7X,'8',7X,'9',6X,'10')
106   FORMAT('+',4X,'--------  ---------  ---  ---  ---  ---  ---  ---
     1  ---  ----')
107   FORMAT(' ',7X,I2,10X,I4)
108   FORMAT('+',34X,10(I4,4X))
      END
```

PROGRAM 3

```
LEVEL  18          MAIN          DATE = 71154          2373
      DIMENSION NASP(80),MUM(80),BMUM(80),MMUM(80),SBN(10,80),MED(80)
      DIMENSION NSKIP(80)
      DIMENSION N(10,80),BN(10,80),PRCNT(10,80)
      DIMENSION MMUM(80)
      DIMENSION NBN(80)
      CALL REREAD
      WRITE(6,113)
      WRITE(6,114)
C
C     THIS SECTION INITIALIZES THE COUNTERS
C
      DO 45 I=1,80
      MUM(I)=0
      NBN(I)=0
      DO 15 J=1,10
      N(J,I)=0
   15 CONTINUE
   45 CONTINUE
      DATA IB/' '/
C
C     THIS SECTION TESTS FOR BLANKS IN 'A' FORMAT
   69 READ(5,111,END=99) (NASP(I),I=1,80)
      DO 10 I=1,80
      NSKIP(I)=999
      IF(NASP(I).NE.IB) GO TO 10
      NSKIP(I)=I
   10 CONTINUE
C
C     THIS SECTION READS DATA IN 'I' FORMAT
C
      READ(99,111) (NASP(I),I=1,80)
      DO 20 I=1,80
      IF(I.EQ.NSKIP(I)) GO TO 20
C
C     THIS SECTION TABULATES ANSWERS INTO GROUPS
C
      JAM=NASP(I)
      IF(JAM.EQ.0)JAM=10
      DO 55 J=1,10
      IF(JAM.NE.J) GO TO 55
      N(J,I)=N(J,I)+1
   55 CONTINUE
   20 CONTINUE
      GO TO 69
   99 DO 26 I=1,80
C
C     THIS SECTION SUMS UP ALL RESPONSES TO GET TOTAL
C
      DO 105 J=1,10
      MUM(I)=MUM(I)+N(J,I)
  105 CONTINUE
C
C     THIS SECTION CONVERTS COUNTERS AND SUMS TO FLOATING POINT
C
      DO 65 J=1,10
      BN(J,I)=N(J,I)
   65 CONTINUE
      BMUM(I)=MUM(I)
      WRITE(6,112) I
C
C     THIS SECTION COMPUTES AND PRINTS PERCENTAGES
C
      DO 75 J=1,10
      PRCNT(J,I)=(BN(J,I)*100)/BMUM(I)
      WRITE(6,103)J,N(J,I),PRCNT(J,I)
   75 CONTINUE
      WRITE(6,106)
      WRITE(6,107)MUM(I)
C
C     THIS SECTION DETERMINES THE MEDIAN
C
      MMUM(I)=MUM(I)/2
      DO 30 J=1,10
```

```
G LEVEL  18                    MAIN                    DATE = 71154
      ABN(I)=ABN(I)+N(J,I)
      IF(YYUY(I).LT.ABN(I)) GO TO 120
      GO TO 30
  120 MED(I)=J
      GO TO 150
   30 CONTINUE
  150 WRITE(6,102) MED(I)
   26 CONTINUE
  102 FORMAT('1',5X,I2)
  103 FORMAT(' ',5X,I2)
  106 FORMAT('+',21X,I2,11X,I4,9X,F5.2)
  107 FORMAT(' ',34X,'----')
  108 FORMAT(' ',34X,I4)
  110 FORMAT(' ',22X,'THE MEDIAN RESPONSE IS ',I2)
  111 FORMAT(80A1)
  113 FORMAT('1',33X,'NUMBER')
  114 FORMAT(' ',5X,'QUESTION     RESPONSE     RESPONDING     PERCE
      END
```

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13. ABSTRACT

This thesis explores the potentialities and survival problems of a Human Resources Management Program in the U. S. Navy and proposes a technique for measuring its potential impact on the Naval organization. The intended application of this work is to the practice of human resources management in the context of the U. S. Navy from both a theoretical and practical viewpoint. The proposed measurement technique is designed to provide a type of "third level" information, more specific than currently exists, which is deemed critical to the real-time application of this emerging practice. The main premise of the thesis is that such contributions of increased analytical measurement capabilities in human resources management will be the critical factors at present in determining if, in reality, this "humanized" approach to naval management will pass its first test of survival in the existing organization. Such a test is its ability to define its role and capabilities to others and to produce some "scientifically acceptable" measure of its impact on Navy organizations.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Human Resources Management						
Measurement Techniques						
Multidimensional Scaling						

The computer data and other output on pages 69 to 92 when reproduced was not easily readable. The author was contacted and in response to our request for a clearer copy stated that the program included in these pages is now (December,1972) considered out-of-date. He indicates that he will be glad to discuss the program and the more recent versions of it with anyone interested. He may be contacted:

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